European Journal of Scientific Research

ISSN: 1450-216X / 1450-202X **Volume 98 No 3 March, 2013**

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European Journal of Scientific Research

Volume 98 No 3 March, 2013

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.288-292
http://www.europeanjournalofscientificresearch.com

Study on the Mechanical Properties of the Multi Component Blended Concrete

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Abstract

The concrete is prepared by blending with various admixtures to cater to the advanced needs and requirements. The addition of admixtures in the concrete and preparation of the blended concrete have paved the way to make the best use of the available admixtures, mix proportioning and other factors to produce the concrete satisfying the higher performance requirements. In this research work, a multi component blended concrete was prepared by replacing cement with various admixtures such as fly ash, silica fume, rice husk ash and calcium nitrate. The percentage of each component was decided after several trials. Then the optimum quantity of admixture that enhanced the property of the concrete was used and concrete specimens were prepared and studied for various durations of 28 days, 56 days, 90 days, 120 days and 180 days for M25 grade of concrete.

Keywords: Fly ash, silica fume, rice husk ash, calcium nitrate, mechanical properties.

1. Introduction

Concrete is the most widely used man made construction material in the world and it is the second to water as the most utilized substance on the planet (Gambhir 2009). A tremendous infrastructure development has taken place in the country (throughout the world) and making of the concrete for higher strengths to cater to the requirements is significant. Admixtures are the chemical compounds in concrete other than cement, water, fine aggregate and coarse aggregate and mineral additives that are added to the concrete immediately before or during mixing to modify the properties of the concrete Tarun et al (1996), Tsivilis et al (1999), Bouzoubaa et al (2001). Based on several trials, it was observed that, for the combination of 2.0% fly ash, 2.0% silica fume, 1.0% rice husk ash and 3.0% calcium nitrate, a better result in terms of both the mechanical and durability properties were obtained comparatively with respect the conventional concrete specimens. The study was carried out for 28 days, 56 days, 90 days, 120 days and 180 days for M25 grade of concrete and elaborated in this article. In this study CON represents conventional concrete and ADM represents the concrete prepared with 2.0% fly ash, 2.0% silica fume, 1.0% rice husk ash and 3.0% calcium nitrate.

2. Materials used and Procedure

The fine aggregates used were clean, containing sharp and angular grains and well graded one. The coarse aggregate occupies more than 50% - 60% of the volume of the concrete and their impact on various properties of the concrete is considerable. The cement used was well grinded, easily workable and offers good resistance to the moisture. The cement used was 53 Grade OPC conforming to IS 12269-1987 (1997). The water used in this study was portable water. The portable water used was confirming to the requirements of IS 456-2000 (2000).

2.1. Fly Ash

Fly ash is a solid, a fine grained material resulting from the combustion of pulverized coal in thermal plant. It is basically a waste product, and mechanical dust collectors or electrostatic precipatators collect the ash. The principal constituents of fly ash mostly are as follows (Gambhir 2009) as shown in fig.1.

1.	Silicon dioxide	30 to 60%
2.	Aluminium Oxide	15 to 30%
3.	Un burnt fuel (carbon)	up to 30%
4.	Calcium Oxide	01 to 07%
5.	Magnesium Oxide	Meager amounts
6.	Sulphur trioxide	Meager amounts

Figure 1: Fly ash

Figure 2: Silica fume

2.2. Silica Fume

Silica fume, which is also called as micro silica, is a by-product of the manufacture of silicon and ferrosilicon alloys in an electric arc furnace. The silica fume has extremely high pozzolanic characteristics and its use has revolutionized the concrete technology. With the incorporation of silica fume in concrete, with respect to other pozzolanas, it is possible to achieve both the higher earlier strength as well as later age strength. It can be used in proportions of 5-10% of the cement content in a mix (Santhakumar 2008) as shown in fig.2.

2.3. Rice Husk Ash

Rice Husk Ash (RHA) is the product of burning rice husk. If the husk is burned under controlled conditions the product has been found to be pozzolanic in nature. It possesses the attribute of high reactivity and can be used in high performance concrete to enhance the property of the concrete. The reactivity of the RHA depends upon the chemical composition of the ash, the processing technology applied surface area and amorphous silica as shown in fig.3

2.4. Calcium Nitrate

Calcium Nitrate is a soluble chemical admixture which when added to concrete interact with the hydrating cementations system by physical, chemical or physic-chemical action, modifying one or more properties of concrete in the fresh and hardened state. By adding it, it is possible to either to increase the consistency without increasing the water content, or to reduce the water content while maintaining a given consistency. It can also slow down corrosion of steel reinforcement in concrete. as shown in fig.4.

Figure 3: Rice husk ash

Figure 4: Calcium Nitrate

2.5. Mix Proportion

The concrete mix was designed for M25 grade of the concrete to study the various properties of the concrete as per IS 10262-1982 (1998). The concrete mix is designed to be

1: 1.27: 2.82 and w/c =0.46.

Compressive strength tests were carried out on 150mm x 150mm x 150 mm cubes as specified by IS 516-1959 (1989). The tensile strength tests were carried out on concrete specimen of size 150mm diameter and 300mm length conforming to the specifications IS 5816-1970 (1985). The size of the concrete specimen used for carrying out this test was of size 100mm x 100mm x 500mm prism. This test was carried out by using 5000 KN capacity flexural strength testing machine subjected to two point loading to determine the flexural strength of concrete as per IS 516-1959 (1989).

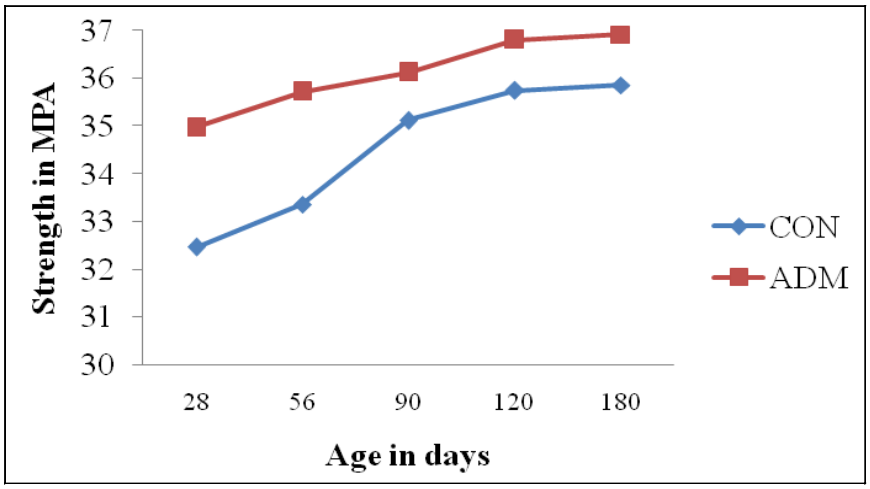
3. Result and Discussion of Mechanical Properties

Compressive Strength

The compressive strength of M25 grade of the conventional concrete (CON) is 29.96 MPa after 28 days, 30.86 MPa after 56 days, 32.62 MPa after 90 days, 33.24 MPa after 120 days and 33.36 MPa after 180 days. The compressive strength of the admixture added concrete (ADM) prepared by adding 2.0% fly ash, 2.0% silica fume, 1.0% rice husk ash and 3.0% calcium nitrate is 32.07 MPa after 28 days, 32.82 MPa after 56 days, 33.22 MPa after 90 days, 33.91 MPa after 120 days and 34.02 MPa after 180 days.

It is observed that the compressive strength of the concrete prepared by adding 2.0% fly ash, 2.0% silica fume, 1.0% rice husk ash and 3.0% calcium nitrate is 7.04%, 6.54%, 2.00%, 2.24% and 2.20% respectively higher than that of the conventional concrete after 28 days, 56 days, 90 days, 120 days and 180 days of testing which are shown in the figure 5.

Figure 5: Strength Variation Vs Age of the Concrete – M25 Grade

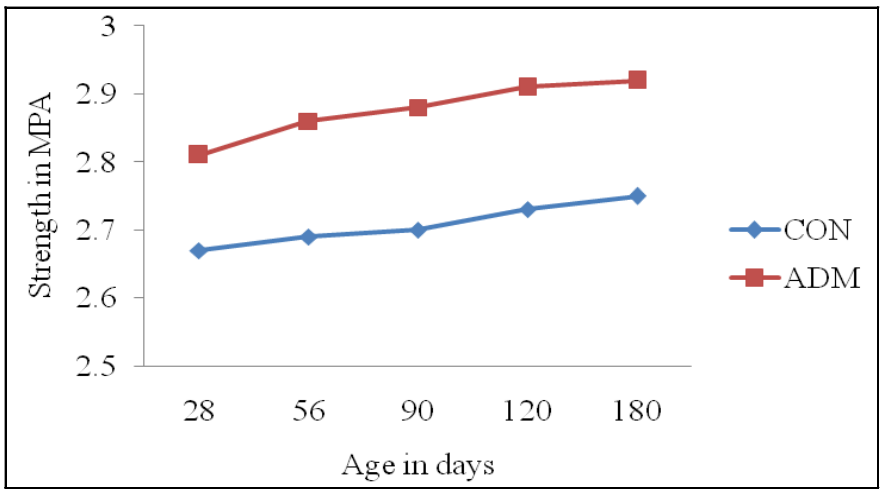


Tensile Strength

The tensile strength of M25 grade of the conventional concrete is 2.67 MPa after 28 days, 2.69 MPa after 56 days, 2.70 MPa after 90 days, 2.73 MPa after 120 days and 2.75 MPa after 180 days. The tensile strength of the concrete prepared by adding 2.0% fly ash, 2.0% silica fume, 1.0% rice husk ash and 3.0% calcium nitrate is 2.81 MPa after 28 days, 2.86 MPa after 56 days, 2.88 MPa after 90 days, 2.91 MPa after 120 days and 2.92 MPa after 180 days.

It is observed that the tensile strength of the concrete prepared by adding 2.0% fly ash, 2.0% silica fume, 1.0% rice husk ash and 3.0% calcium nitrate is 0.47%, 0.57%, 0.60%, 0.60% and 0.57% respectively higher than that of the conventional concrete after 28 days, 56 days, 90 days, 120 days and 180 days of testing which are shown in the following figure 6

Figure 6: Tensile strength Vs Age of M25 grade of concrete

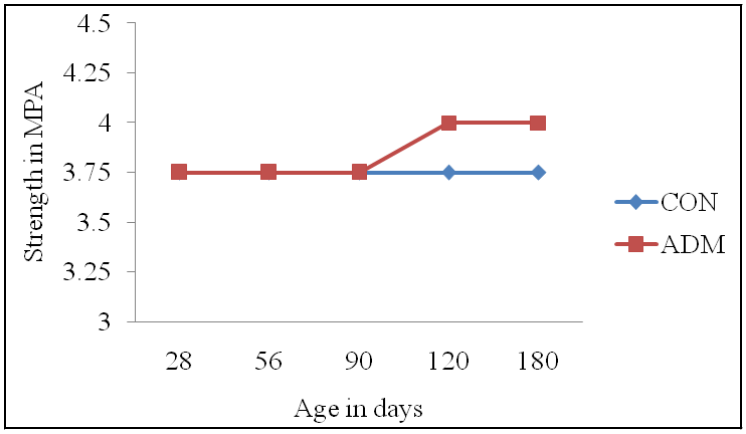


Flexural Strength

The flexural strength of M25 grade of the conventional concrete is 3.75 MPa after 28 days, 3.75 MPa after 56 days, 3.75 MPa after 90 days, 3.75 MPa after 120 days and 3.75 MPa after 180 days. The flexural strength of the concrete prepared by adding 2.0% fly ash, 2.0% silica fume, 1.0% rice husk ash and 3.0% calcium nitrate is 3.75 MPa after 28 days, 3.75 MPa after 56 days, 3.75 MPa after 90 days, 4.00 MPa after 120 days and 4.00 MPa after 180 days.

It is observed that the flexural strength of the concrete prepared by adding 2.0% fly ash, 2.0% silica fume, 1.0% rice husk ash and 3.0% calcium nitrate is 0.00%, 0.00%, 0.00%, 1.83% and 1.83% respectively higher than that of the conventional concrete after 28 days, 56 days, 90 days, 120 days and 180 days of testing which are shown in the figure 7

Figure 7: Flexural strength of M25 grade of concrete



4. Conclusion

Based on the results it can be concluded that by the addition of multi component admixtures, a good improvement in compressive strength properties of concrete is identified and proved. Initially the compressive strength of the concrete is roughly 7.0% higher than that of the conventional concrete and it later on reduces to 2.0%. As far as the tensile strength of the concrete is concerned, there is only a marginal increase in tensile strength ranging between 0.3% to 0.8%. There is no change in flexural strength for the period of 28days, 56 days and 90 days of testing. But for 120 days and 180 days, there was an increase of 1.83%. Hence it is concluded that by the addition of multi component admixtures, a good improvement in the strength property is observed.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.293-301
http://www.europeanjournalofscientificresearch.com

Nigeria's Need for Social and Economic Transformation

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Abstract

This paper argues in defence of the thesis that Nigeria is in need of social and economic transformation and maintains that Nigeria's present social order allows individual interests to conflict with the overall national interest of Nigerians. The paper argues that any postulation that is opposed to change cannot be an effective basis for social reform in Nigeria. This paper is a contribution to the vision that Nigerians can and should reform Nigeria's social, economic and political systems. The paper maintains that educated Nigerians owe the Nigerian people the duty of making them realize how they are being exploited and give them the power to make changes in society. In view of that, the paper emphasizes the need for educational and legal reforms in Nigeria, which will in turn usher in the required social and economic transformation in Nigeria.

Keywords: Social and Economic transformation, Social Order, National Interest.

Nigeria's Present Social Order

In the second stanza of Nigeria's National Anthem, precisely the last three lines, Nigerians pledge to live just and true; to attain lofty heights for the individual selves and for the nation, to build a nation where peace and justice shall reign. In the oath of office for members of the National Assembly, each member of that legislative body pledges commitment to the well-being and prosperity of the Federal Republic of Nigeria. As members, each is in principle free to support those policies and activities, which in his or her opinion are in Nigeria's national interest (*Constitution of the Federal Republic of Nigeria*, *1999*). Often, however, the contractual obligations, which they owe the Nigerian society, are largely set aside in the name of party supremacy. According to Idris Gidado: "party members were often and are still often enjoined to toe party lines in all their actions in the National Assembly, even those that may be to the detriment of Nigeria" (6). Herein lies the conflict. In the exercise of their duties in the Senate and in the House of Representatives, members are saddled with lobbying machinery set up by the party or the executive.

Nigeria's present social order upholds the type of national sovereignty where the interest of political parties are allowed to conflict with the interests of the Nigerian nation. Should a Nigerian political party habour and defend interests that are to the detriment of Nigeria? The Nigerian nation is supreme and superior to all Nigerian political parties. In modern political thoughts, freedom of expression is presupposed as a fundamental human right in the absence of which greed, tyranny and venality reign supreme. The *Constitution of the Federal Republic of Nigeria 1999* expressed this modern disposition when it said that: "sovereignty belongs to the people of Nigeria from whom government, through this Constitution derives all its powers and authority" (14:2A). No doubt about

that. Theoretically sovereignty belongs to the generality of the Nigerian citizenry. But does sovereignty belong to the generality of the Nigerian citizenry in practice? The answer is no, and therein lies the missing link. This missing link points to the need for a new social order in Nigeria that will subordinate the interest of any and every political party in Nigeria to the interest of the nation. Under such a new social order, when conflict arises between the interest of a given political party and the overall interest of the nation, the interest of the party will be subordinated to that of the nation. There are many reasons why Nigeria stands in need of social and economic transformation. Three perhaps stand out as having a major impact on the shape and content of this paper. The first is the issue of the type of social order that exists in Nigeria. The second is the issue of subordinating individual to a higher social totality and the third is the issue of regarding Nigeria as an organic whole. Reflections on these and others lead to our organizing the paper around what we consider the biggest and most important issue of all, namely, how to build up commitment to the ideals of the Nigerian nation, the fact of her numerous diversities notwithstanding.

There is need here to say a word about social sciences as sciences. Some people argue that unless the social sciences can have the same degree of exactness, certainty and ability to formulate general laws as is found in the physical sciences such as chemistry and physics, the word science should not be used to refer to them. Prominent in this school of thought are philosophers like John Stuart Mill, Ernest Nagel and Auguste Comte. This amounts to being dogmatic and here philosophy comes in to help science. As Alozie rightly puts it, querying the results of scientific investigations will prevent science from becoming a dogma (204). This is one of the ways philosophy helps scientists to break new grounds. Alozie makes a very valid point in this direction, namely, that,

> Politics is wrongly divorced from its material and ideological connectedness. This lopsided view of politics has made some people assert that politics cannot be subjected to a scientific treatment. Thus, political science or the study of politics was initially not regarded as science in consonance with the tradition of positivism. Political science is part and parcel of social science. (Philosophical Foundations, 206)

When, however, political science or social science analysis concentrates attention on how to import capitalist values, capitalist institutions and capitalist development into the developing countries, and, with various intrigues, forces these countries to accept them, then in that sense and to that extent, it ceases to be science and becomes imperialism (Ake, Claude, quoted in Alozie, Philosophical Foundations, 206).

Alternative Models for Building the Nigerian Nation

Nigeria has been a federation since 1954, when the Lyttleton Constitution devolved it into a central government and three regional governments. From then till the present, Nigeria has been a federation except for a brief period in 1966 when, under late General Aguiyi Ironsi, Decree No. 34 of 25th May, 1966 established a unitary system, which was abolished by Decree No. 59 of 1966, which returned Nigeria to a federal system under General Yakubu Gowon. There are, however, some postulations of alternative models for nation building including a socialist alternative to the prevailing bourgeois order. This is the panacea of socialism. This is a view of socialism as a probable solution to the problem of stability and leadership continuity in Nigeria. In this regard, there are two clear schools of thought: One Marxian, the other Welfarist.

Two members of Nigeria's 1976 Constitution Drafting Committee, Yusuf Bala Usman and Segun Osoba wrote what has been called the "Minority Draft Constitution" (1976). This paper of theirs represents till date, a clear formulation of the Marxist Socialist approach to the future of Nigeria's government. They argue that poverty, disease and acute want of basic essentials are the most apparent and pervasive features of the living conditions of the common people of Nigeria. These people-peasants and workers – constitute over ninety percent of the Nigerian population. The argument is that the crucial aspect of their conditions of existence is their role in the system of production and the

degree to which they control this system to serve their interests, which are in a very direct way the interest of the nation. It should be noted here that Karl Marx's *Communist Manifesto* is subjective in many respects. Marx considers, for example, that the bourgeoisie's only contribution to the production process is their capital. But entrepreneurship is as important as capital itself. Also Marx propounded that as production developed, some of the capitalists would break away and join the proletariat. The opposite is the case today. In his own opinion, the ranks of the capitalists would thin down while that of the proletariat would continue to swell up. In the course of time, the proletariat would overthrow the capitalists and seize the rein of power in each country. All of them would unite and form some sort of a world government where peace would reign supreme. But the reverse is the case. The world is plagued with conflicts among nations, contrary to Marx's expectation. Marxian solution to Nigeria's problems is completely unacceptable. According to Yusuf Bala Usman and Segun Osoba, a collectivist society with socialist orientation and the control of state power by peasants and workers guided by revolutionary theories, developed in their own historical experience and independently applied is greatly desirable. Though not yet possessed, it is according to them, something much wanted. In the words of Karl Marx, "Philosophers have interpreted the world in different ways; but the task is to change it" (568). In the vision of Usman and Osoba, Nigerians can and should change Nigeria from a capitalist or bourgeois state to a socialist state.

In spite of the above efforts of Yusuf Bala Usman and Segun Osoba, alongside other well-meaning Marxist scholars, the strategy and thinking of another socialist school of thought, the welfarist, have been winning considerable support in Nigeria. And here one finds the late Obafemi Awolowo to be at his best in terms of theoretical activity. According to Awolowo in this direction:

> We will not for a moment gloss over the fact that federalism and democracy… require no ordinary type of leadership…toleration, breath of outlook, intellectual comprehension, hardwork, selfless devotion, statesmanship, a burning sense of mission; these are some of the virtues which leaders who want to make a success of federalism and democracy in Nigeria must possess (159-160).

Federalism is a principle employed by a system of government where the power within a nation is shared between a central government and its units – regions or states as the case may be – whereby each level of government is autonomous within its own sphere of operations. In the words of Bertrand Russell,

> Philosophers are both effects and causes; effects of their social circumstances and of the politics and institutions of their time; causes (if they are fortunate) of beliefs which mould be politics and institutions of later ages (7).

The need to distinguish between genuine and fake solutions to the problems of the Nigerian nation justifies this paper. Any postulation or solution that is opposed to change cannot be an effective basis for social reform in the Federal Republic of Nigeria. Talking about the origin of federalism, Shridath S. Ramphal, according to Akinyemi et al. says: "Federalism did not begin as a concept of social and political organization evolved by reflective philosophers or postulated by didactic political scientists, it did not sprout from a process of a priori reason. It is not a political ideology" (xiii). Here the findings of a team of scholars at the Centre for International Studies at New York University, who conducted an enquiry into "the requisites for successful federalism" are quite illuminating. Their findings show that the principal causes of failure or partial failure of each of the federations studied was not to be found in any analysis of economic statistics or in an inventory of social, cultural or institutional diversity but "in the absence of a sufficient political – ideological commitments to the primary concept or values of federalism itself" (Akinyemi et al xiii). They found that in each case, this primary commitment to the federal ideal as a primary goal did not exist at the moment of federation, the moment of coming together, and had not yet been generated subsequently. The report further showed that the presence of certain secondary factors such as a common colonial heritage, a common language, the prospect of complementary economic advantages, while useful and at times necessary, are never sufficient to ensure success. These values are useful to the extent that they build up a

common commitment to the primary goal of federalism (Akinyemi et al xviii - xix). The team of scholars came to the conclusion that:

> For a federation to be able to resist failure, the leaders and their followers must "feel federal" – they must be moved to think of themselves as one people with one common self interest – capable, where necessary of over-riding most other considerations of small group interest. It is not enough that the units of a potential federation have the same ideal of the good but that "the good" for anyone must be consciously subordinate to or compatible with "the good for all". This, then, is tantamount to an ideological commitment, not to federation only as a means – such as for example, a means to gain independence or financial stability, to utilize secondary or tertiary factors – but to federation as an end, as good for its own sake, for the sake of answering the summons of history (xix).

So the problem is how to make Nigerians "feel federal". How does one make Nigerians think of themselves as one people, with one common self interest capable, where necessary, of over-riding most other considerations of small group interest? How can one make Nigerians realize that for their federation to be able to resist failure, "the good" for any one or group must be consciously subordinate to or compatible with "the good for all"? How does one make Nigerians accept this and the fact that their federation is not merely a means to their selfish goals, a well-baked national cake for every one to struggle to cut a share from? How can one make Nigerians accept the fact that Nigeria is also an end; a good for its own sake, a national cake to be baked for the sake of answering the summons of history? Without virtue, republican governments cannot stabilize, they cannot prosper. Virtue for Montesquieu, according to Ochulor, is the love of ones country and the preference of the interest of one's country to one's self-interest. Virtue for Montesquieu means moral goodness (Philosophical Foundation, 321).

Regarding Nigeria as an Organic Whole

Nigeria's problem as a nation is how to change the socio-economic policies and political endeaviours, which are embedded in capitalism. Alozie, a prominent Nigerian scholar, is clear on this issue:

> Political practice derives from the material or economic foundation of society. The contradictions in the Nigerian capitalist oriented economy appear as social and political contradictions. The failure of the previous governments of the Nigerian state to abandon the exploitative capitalist system which produced the crises and contradictions; the inability to replace this system with its alternative system (socialism) makes us draw the conclusion that … things will definitely be rougher in the country at large unless there is social reform (85).

This paper emphasizes the need to reform Nigeria's social, economic and political systems. Nigeria needs a social order opposed to the prevailing capitalist system. It must be noted here that in the world today, capitalism is veering towards socialism while socialism is veering towards capitalism. What Nigerians need today is a welfare state along British lines rather than a social revolution along Marxian lines. That is, in the opinion of this paper, the surest way to disarm the exploiters of the people. Princewill Alozie in 1994 took time out and discussed the philosophical foundations of Nigeria's socio-economic and political systems. The work titled "Philosophical Foundations of Sciences and Politics" was published in the volume: *History and Philosophy of Science.* In the elegant work, the author argues that "… there is the need for restructuring the neo-colonial economy and the political system it has given birth to. This restructuring will have to take another form, aimed at satisfying the basic needs of the majority of the Nigerian populace" (Philosophical Foundations, 207). Though he used the structure of racial domination and the character of contemporary South Africa, in a manner that was both successful and effective, to illustrate the philosophical foundations of politics, Nigeria's socio-economic and political systems were brought into clear focus. According to him, "understanding the nature of a state is important for those who wish to appreciate the structure of racial

domination in South Africa, as well as for those who do contemplate the changing of a particular social order. The character of the state dictates the kind of government that serves the state, although there are occasions when a government influences the character of the state. The institutions that define the nature of the state have to be changed if a new social order is to be truly effected" (Philosophical Foundations, 207). After a rigorously philosophical analysis of the structure of racial domination and character of contemporary South Africa, with occasional and important attention focused on the character of contemporary Nigeria and other African states, he goes on and makes the all important point:

> Much as the change of guards in the government house in South Africa is salutary, the social and economic structures that sustained apartheid regimes for those years are still in place. What is more, it appears that those very structures have decided to allow Africans have political power while the main foundation of politics – the economy – continues to be in the hands of the Multinational corporations. This position … better explains the politics of South Africa, Nigeria, and indeed, the developing countries than any other philosophy taken singly (Philosophical Foundations, 208).

His examination of the South African situation reveals the ugly fact that the multinational corporations and financial institutions dehumanize, exploit and trivialize the lives of Africans in the various African states. Any sincere African who is well equipped to assess the situation on ground, will sooner than later appreciate the point he is making. The philosophy underlying those international organizations is capitalism, which more often than not, promotes and encourages ruthless exploitation and at times, these are done in a manner that can deceive the unsuspecting masses into thinking that the capitalists are protecting their interests. The great mistake of many African leaders, he argues, is that of falsely believing that these multinational corporations can bring economic prosperity to Africa and so such misinformed African leaders welcome them. The multinationals only favour their agents to the extent these agents remain instruments of exploitation in favour of the multinationals and their imperialist countries. Chinweizu's poem: "On Welcoming Predators" which Alozie cites to drive home his point here fits in excellently well and paints a clear picture of what the position is. Here, the tiger stands for the multinational corporation while "he" stands for the misinformed African leader: "With open arms he welcomed a smiling tiger into his home. With open jaws the tiger welcomed him into his belly. After all smiled the beast, one good welcome deserves another".

The trouble with Nigeria, as Chinua Achebe rightly observed "is simply and squarely a failure of leadership" (1). By virtue of her population and wealth, Nigeria is the greatest source of hope for the black race. But to make it, Nigeria needs the right type of leadership for many years to come. She needs leaders who will see things steadily and see them whole. Nigeria need social and economic transformation. Men and women of intelligence and uncompromising integrity must have the final say in the affairs of Nigeria and rule her for several years to come. In Plato's opinion, according to Ochulor, the guardians or leaders must be free not only from the temptation to acquire property but also from the temptation to prefer the advantages of their respective families to those of the state (Failure of leadership, 1). It is the responsibility of government to ensure that no selfish and greedy members are allowed to deprive others of their fair share of the common property of the whole society by grabbing too much for themselves alone. The required leaders must have a great deal of self-discipline, selfless spirit, vision and a deep appreciation of Nigeria's basic problems. Leaders who possess these qualities could infuse into Nigerians the discipline and massive re-orientation of their life outlook so badly needed. They must mobilize the people and resources, fight and completely destroy neo-colonialism and all forms of exploitation. They must put the greatest emphasis on education, science and technology and build a modern self-reliant economy that will be based on the imaginative adaptation of capitalist and socialist ideas to Nigeria's peculiar circumstances, until Nigeria becomes a great modern nation like United State of America, Japan, China, Britain etc. This paper is a contribution to the vision that Nigerians can and should change Nigeria from a capitalist or bourgeoisie state to a welfare state based on the imaginative adaptation of both capitalism and socialism to

Nigeria's advantage. Nigeria needs a philosophy committed to change. Marx strongly emphasizes the fact that; "Hitherto the philosophers have only interpreted the world differently, the point, however is to change it" (568).

Nigeria's economic system, argues Iwe, a prominent Nigerian scholar, should be based on a definite and sound social philosophy, a form of socialism relevant to Nigeria's needs as a nation" (24). What Nigeria needs today is a welfare state along British lines. Capitalism and socialism are both human systems and no human system is perfect. The success or failure of any of them depends largely on the operators of the said system. The largest economy in the world today is United States of America, seconded by Japan. Both of them are capitalist countries. The third largest economy in the world today is China and China is a socialist country. This shows, as Professor W. Arthur Lewis rightly argued, that capitalism and socialism are capable of bringing about a good deal of economic development. At the end of the second World War in 1945, the economy of Japan was completely ruined. But in about fifty years 1950 – 2000, Japan has performed an economic miracle. She is a leader in automobiles, ship building, electronics and fishery. She is one of the leaders in other spheres of production. Japan is the only country in the world with no unemployment whatsoever. She has a favourable balance of payment against every country in the world, including United States of America. The West is now borrowing heavily from Japan's technology. In the words of Eskor Toyo

> Among the G-7 nations, there has been much compliant about Japanese protectionist trade restrictions. The consequence is that Japan has a huge trade surplus with other countries. What this means is that the Japanese concentrate on selling to others and do little buying from others. Globalization means that Japan should buy more from others (37).

Nigeria's embassy in Japan must promote trade for Nigerian products with zeal and commitment and must not turn Nigerians into mere consumers of Japanese products. Many have accepted Marxism completely; others have modified it to suit their specific needs, and some have refused it completely. Nigerians cannot afford to reject Marxism completely. Nigeria needs social and economic transformation. This author once argued for a sovereign national conference in Nigeria to determine the nature of the needed social and economic transformation. Better reason has, however, now prevailed. Majority opinion does not necessarily make a position right and the powerful and greedy members of the Nigerian society will never allow equitable distribution of the common good. Marx writes that the history of all societies is the history of class struggle. Each person belongs to a certain socio-economic group within the society. That some Nigerians have so much of the common good while some others have none is part of the contradictions of capitalism. Nigeria is in dire need of social, economic and political reforms. In other words, Nigeria's political economy needs radical transformation. It must be noted that the rigging of elections in Nigeria is the worst thing that happens to Nigeria. The political class arms the thugs for war at elections. At the end of elections, the thugs are not disarmed and they turn the weapons at their disposal against society. This is the situation in which Nigerians find themselves today. This is a source of armed robbery in Nigeria. This is a source of various kinds of violence in Nigeria. Good governance is a "sine qua non" for economic development, and to get good leaders, Nigerians must eradicate the evil of election rigging which leads to other forms of corruption in Nigeria. Nigeria is among the most corrupt nations of the world. "According to the perception index of Transparency International, Nigeria was ranked 144th out of the 146 countries, beating Bangladesh and Haiti to last position" (Uduma, 16). Corruption has eaten deep into the fabric of the Nigerian nation:

> In a 1994 survey among international experts who attended conferences on corruption of countries as regards the seriousness of their problems with corruption, Nigeria was ranked among the highest. In the 1996 survey conducted by a German-based non-profit organization formed to fight corruption, Transparency International, Nigeria was rated among the most corrupt countries in the world. Similarly, in the

> reports of 2000 and 2002, the T.I. identified Nigeria with the same disease. Actually corruption has become a way of life for some Nigerians (Mamadu, xi).

There is great need to rid Nigeria of corruption. Adequate separation of governmental powers with a fearless and consistent application of checks and balances in government will greatly redress misrule in Nigeria and with time rid Nigeria of corruption. Nigeria is one of the twenty countries in the world with the greatest degree of income inequality. The World Bank estimates that 54.4% or 76 million Nigerians are poor. And yet Nigeria has some of the richest men in the world (Mamadu, 84). Ridding Nigeria of corruption will gradually correct the extreme inequality in Nigeria.

Need for Educational and Legal Reforms in Nigeria

Educated Nigerians owe the Nigerian people the duty of making them realize how they are being exploited and give them the power to make changes in society. Much of what passes for present education in Nigeria is really indoctrination to enslave the masses to existing economic, political and social systems. Nigeria needs a decisive reform in education in order to effectively meet her leadership responsibilities. Education played an important role in "Russia's miracle of development". At the time of the "October Revolution" in 1917 and the overthrow of the old aristocracy and its ideals, three quarters of the population were unable to read and write. The Bolsheviks as soon as they obtained power in 1917 decided to raise educational standards and they gave formal and political education the highest priority. There is need for educational reform in Nigeria. Nigerians have enough resources to guarantee free and qualitative education at all levels. This does not mean that every Nigerian school child should have the same opportunity of becoming a top class engineer. Rather those who at a certain stage show that they are not gifted with such abilities will be directed into a type of schooling, which is suitable for them and for the nation. A moment's rational analysis here will show that this is precisely what Socrates meant when he said that it is the duty of the educator to diagnose the arête – the excellence or ability of every individual and then to train him accordingly. In this way, the individual will benefit himself and the state to the best of his ability. The underlying principle here is "from each according to his ability, to each according to his needs". There is need for educational reform in Nigeria because Nigeria's educational system is sick. Japan had her first University, namely, University of Tokyo in 1877. And yet Japan has sixty four Universities today. Nigeria had her first University in 1948 in Ibadan. Nigeria now has over 90 Universities today, most of them State and private Universities. None of Nigeria's Universities is among the best five hundred in the world. Only four Universities in Nigeria are among the best fifty in Africa. Obafemi Awolowo University, Ife is among the best fifty in Africa. It is interesting to note that Obafemi Awolowo University is the forty fourth of the best fifty in Africa. There is great need, therefore, for Nigeria to reform her University system with the aim of maintaining high educational standard. Japan is leading the world today in many spheres of human endeavour because her educational system is second to none – in terms of quality. Nigeria can do the same through a fearless war against all forms of corruption.

There is need for teachers in Nigeria to guard against being instruments of capitalist or socialist indoctrination. The students themselves need a clarified and meaningful approach to the educational process to enable them discover undue indoctrination. Analysis is important here because many of the texts approved for schools are books that carefully omit critical discussions of certain political, social and economic policies because of the offence such critical discussions, which may present policies in unfaviourable light, are likely to cause in certain quarters. As articulated by Ozmon and Craver.

> Marx believed that educators could make people realize how they are being exploited and give them the power to make changes in society. Marx felt that basically everything is a result of various economic forces that operate in a dialectical way. Education is also shaped by economic changes and in turn helps to create new changes. Marxists argue that most of what passes for present education is really indoctrination to enslave the masses to existing economic, political and social systems. The "hidden

> curriculum" teaches docility and subservience to the present system. They believe that such education must be eradicated if we are to prevent exploitation and move toward a world of economic and social justice. In order to do this, students must be exposed to new and radical points of view and encouraged to become agents for charge in building a better society (262).

Most teachers in Nigeria are being used, without their knowing it, by the capitalist enterprise as agents to indoctrinate their students with values inherent in Nigeria's capitalist economic system. The students themselves are more often than not, unaware of this ugly fact.

There is need to indicate that many of the laws in Nigeria merely express the will of the ruling class and are used to oppress the toiling masses. The ruling class uses the same laws to guarantee and defend the interest of the dominant class. An example is Nigeria's Land Use Act of 1978, which vests in the Governor of the State the ownership of all land in the State. It also vests in the Governor the power to revoke a right of occupancy on any piece of land. The state achieves its objectives through "binding rules of conduct" chiefly in the form of legislation established by the ruling class, which assumes observance thereof by the force of its apparatus and constraints: the state or nation (Golumski et al. 336). This enables the capitalist to purchase the labour of the workers to create surplus value for himself. The worker is exploited because his wage is not commensurate with the labour power he extends. Addressing their critics (the bourgeoisie) Marx and Engels argue that: "Your law is merely the will of your class, exalted into legislation, a will whose content is defined by the material conditions of the existence of your class" (79). Marx opined that law observes power relationship. For him, the legal form is an ideological illusion. This is because the same legal system that provides for the right to enter freely into contracts does not provide for equal bargaining powers. As a result, the legal form makes the rich and the poor unequal before the eyes of the law, which is generally thought to be no respecter of persons. George Orwell firmly gave an apt description of the situation when he said "All animals are equal but some are more equal than others" (92). Marx's ultimate solution to man's bewilderment is the introduction of communism which for him, would eliminate class and consequently oppressive laws. For him, the full realization of human nature would be achieved under communism. In communism, people will no longer divide themselves into classes, and instead of the power of production being left in the hands of a few persons, it is harnessed to provide for the wants and needs of all.

Conclusion

The process of history is, according to Marx, a dialectical and revolutionary course that no one can terminate or hinder. Improvement of man's condition is sure and struggle for emancipation cannot be avoided, in view of the fact that history is severely in pursuit of its dialectical course. All the same, Nigerians should not abandon themselves to fate. They should assist history in its revolutionary course to ensure speedy liberation of man from the shackles of capitalist oppression and exploitation. Every Nigerian must appreciate the fact that the rigging of elections is not just bad but evil. It is an evil that works against every Nigerian including those who profit from it in the short run. This paper, therefore, through its analysis above emphasizes the need for social, economic and political reforms in Nigeria. The needed reforms must have an educational approach for re-orientation, re-conscientization and reconstruction. In other words, to bring about the needed social and economic transformation in Nigeria, Nigeria must first reform her educational system and make it second to none in terms of quality in Africa, at least.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.302-309
http://www.europeanjournalofscientificresearch.com

Performance of Application-Oriented Routing in Hybrid Wireless AdHoc Networks

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Abstract

Hybrid wireless networks are a viable networking solution to combat the limitations of infrastructured wireless networks and provide Internet connectivity to ad hoc networks. This paper first analyzes the requirements for deployment of hybrid networks under different application scenarios. Then two routing schemes designed for different traffic patterns in hybrid networks are proposed to achieve optimal performance. Simulation results show that with a large percentage of short web- based traffic sessions, using a gateway as a default router results in better performance with lower latency, fewer routing table entries, and manageable control overhead. When traffic locality is high and Internet traffic is only an occasional occurrence, the reactive routing scheme results in better performance, yielding low control overhead and higher throughput.

Keywords: Hybrid wireless network, deployment, routing schemes, traffic locality

1. Introduction

Infrastructured wireless networks and *ad hoc* networks are two popular types of wireless networks. In infrastructured wireless networks, mobile nodes communicate directly with an access point to the wired network. An ad hoc network, on the other hand, is comprised of mobile nodes that communicate solely over the wireless medium. One difficulty of installing infrastructured wireless networks is to avoid *dead zones* (areas without coverage). Additionally, unidirectional links, which are a common occurrence in wireless networks, can make direct communication with the access point impossible for mobile nodes if the access point has a greater trans- mission range than the mobile nodes. The limitation of ad hoc networks is that there is typically no connectivity between the fixed network and the mobile nodes, due to the lack of pre- existing infrastructure. With the continued growth of interest in ad hoc networks, it is inevitable that global connectivity will be required for mobile wireless devices in the near future.

To overcome the limitations of infrastructured wireless networks and to provide mobile nodes in ad hoc networks Internet connectivity, hybrid wireless networks can be built to broaden usage of wireless networks. As shown in figure 1, multi-hop paths between mobile nodes and access points can extend the coverage of the network and provide Internet connectivity to mobile devices.

While these two types of wireless networks have been extensively studied individually, hybrid wireless networks bring new challenges in protocol design and performance evaluation. Traffic in hybrid networks can be both within the ad hoc network, and to or from nodes in the wired Internet.

Applications for hybrid networks include conference environments. Conference attendees can communicate with each other in a spontaneous network using their mobile devices, and they can also perform Internet-centric tasks such as web browsing or email checking. In a sensor network, sensor nodes can cooperate with each other by exchanging data, while some designated or powerful nodes may transmit this data back to an Internet repository. Other applications include personal networks and many collaboration scenarios.

Because different applications have different configuration and performance requirements, traffic patterns in these scenarios will vary. To deploy hybrid networks, it is important to understand the required elements in terms of hardware and protocols. Further, because the routing protocols for infrastructured networks are based on direct transmission range of the access point, they cannot be directly applied to the multi- hop environment. It is important to investigate new routing schemes that can better adapt to the hybrid networks with different traffic composition and application requirements.

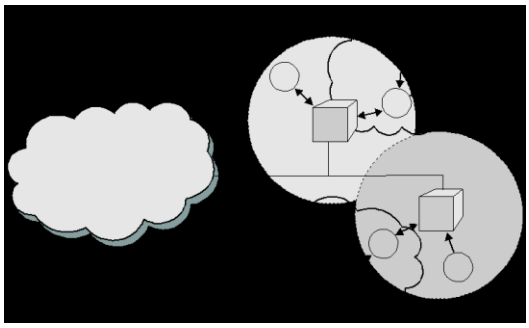
In this paper, we propose two routing schemes for hybrid wireless networks, and evaluate the performance of the proto- cols based on different application scenarios. Both solutions entail the integration of the Mobile IP protocol [4] and Ad hoc On-Demand Distance Vector (AODV) protocol [6]. Our results show that with a large percentage of Internet traffic and real-time applications, routing schemes that utilize a default gateway provide better performance with lower transmission latency; on the other hand, if most traffic is confined to the ad hoc network and the application is not particularly delay- sensitive, on-demand routing schemes are preferred because they generate less control overhead.

2. Related Work

Two initial related studies are presented in [3] and [1] to provide Internet connectivity in ad hoc networks. Both approaches integrate Mobile IP with ad hoc routing protocols to forward data between the wired network and ad hoc net- work. Specifically, [3] uses a modified version of the Routing Information Protocol (RIP) and [1] uses DSR for ad hoc routing.

An alternative solution, MIPMANET, is presented in [2]. In this approach, nodes in an ad hoc network that require

Figure 1: A Hybrid Wireless Network.



Internet access registers with the foreign agent and use their home address for all communication. Mobile nodes tunnel all packets destined for the Internet to their Mobile IP foreign agent. The AODV routing protocol is used to discover routes between mobile nodes and the foreign agent.

Our previous study [8] uses a similar mechanism by integrating Mobile IP with AODV. However, in this approach, data forwarding between the gateway and mobile nodes does not necessitate tunneling. This work also examines the effect of varying beacon intervals on the protocol performance,

and proposes a mechanism for mobile nodes to obtain co-located IP addresses without the existence of Mobile IP.

3. Routing in Hybrid Wireless NetWorks

In this section, we investigate routing protocols for hybrid wireless networks. It is first important to analyze the required elements for the deployment of hybrid networks. As de- scribed in section I, in addition to the mobile ad hoc network, the access point serving as the Internet gateway, where one or more mobile nodes are within its transmission range, are the basic requirements to deploy hybrid wireless networks. Mobile nodes with arbitrary pre-assigned IP addresses can obtain globally addressable co-located IP addresses for Inter- net communication [5]. On the other hand, if a node wants to keep its original IP address, Mobile IP can be utilized; a Mobile IP foreign agent can be deployed at the gateway to provide Internet access to and from the hybrid networks. Finally, it is desirable to use ad hoc routing protocols for traffic within ad hoc networks to obtain optimal routing paths with less traffic centralization at the gateway.

Since multi-hop paths typically exist between mobile nodes and the gateway, as well as between pairs of mobile nodes, the primary issue is to effectively find routes to destinations whether they are inside the ad hoc network or reach- able through the wired network. Because the general location of the destination is not initially known, the optimal design of the routing protocol is likely to be affected by the requirements of the application. We will examine these effects in section IV. The following describes routing approaches for hybrid networks.

3.1. Gateway/FA Discovery

It is important for mobile nodes to know the existence of the Internet gateway or the Mobile IP foreign agent, so that the gateway can be utilized to communicate with wired cor- respondent nodes. In this paper, we focus primarily on net- works with Mobile IP capability. Similar mechanisms can be applied to non-Mobile IP access point/gateway operation.

In infrastructured wireless networks, foreign agent discovery is achieved through periodic Foreign Agent Advertisements. Mobile nodes can also proactively solicit advertisements from available foreign agents. Because these messages can only reach nodes within one hop, they cannot be directly applied to the multi-hop environment.

There are two basic mechanisms for mobile nodes to discover cover a gateway that is multiple hops away [2]. In the first approach, mobile nodes rebroadcast the Agent Advertisement messages so that the advertisements periodically flood the entire ad hoc network. This approach has the advantage of informing new nodes of the presence of the foreign agent, refreshing paths to the foreign agent, and enabling nodes a faster discovery of a foreign agent with lower transmission delay, fewer hops, etc. In the second approach, mobile nodes that require Internet connectivity proactively solicit the foreign agent and advertisement messages are unicast to these mobile nodes.

Previous work [2] has shown that as the number of nodes that desire Internet connectivity increases, the total control overhead of the unicast approach increases and surpasses the rebroadcasting approach. Further, the determination of the better approach for foreign agent discovery depends on the traffic pattern and application requirements. This will be examined in section IV.

3.2. Routing for Hybrid Networks

Because traffic can be either within the ad hoc network or to and from the Internet, a routing scheme is needed that can operate seamlessly in either scenario. Recent studies [9] show that a large percent of the traffic in a local-area wireless network is comprised of web sessions, FTP and mail traffic. Web-surfers often visit one or two sites in a single session and initiate many sessions. No traffic analysis studies for hybrid networks have been performed, but we can predict Internet traffic and application

models in hybrid networks will follow similar patterns. Additionally, usage of hybrid networks will also entail scenarios such as the conference scenario, as de- scribed in section I. These web-centric applications require real-time user interaction with low latency, which demands low communication and processing overhead. Sometimes the sessions are short-lived and a large number of web sessions can target many different web sites, so the processing overhead for discovering and maintaining a large number of routing entries may also be an important issue because of the scarce resource of mobile devices.

Considering the different application requirements, we propose two routing schemes for hybrid wireless networks. The routing schemes can be built on top of any on-demand ad hoc routing protocol with minor changes. For simplicity, we utilize AODV as an example to illustrate the protocols.

Routing Scheme 1*:* When there is a large percent of traffic traversing the wired/wireless gateway, and applications are short web-oriented sessions, it is desirable for mobile nodes to always have a default route to the gateway. This will significantly reduce the route acquisition latency, thereby reducing the data transmission latency. Minimal delay is important to web users, because users cannot tolerate frequent long waiting times for web page retrievals. Also, web users typically visit web pages at multiple domains. Lack of a default gateway would require a route discovery each time a new web server was queried. Further, by using a default route, the processing and caching overhead is significantly reduced, thereby saving the limited resources of mobile devices. The first scheme is geared towards web-centric traffic patterns and provides efficient routing to this type of applications.

In this scheme, foreign agents periodically broadcast

Agent Advertisement messages, and all the mobile nodes re- broadcast these messages. Each mobile node is required to register with the foreign agent. Mobile nodes can also use advertisements to initialize and update the route between the foreign agent and themselves. In high mobility scenarios, where the route freshness cannot be guaranteed solely by bea- con messages, mobile nodes can use ad hoc routing protocols to acquire a route to the foreign agent.

Each mobile node maintains the gateway as its default router. When a node has data to transmit, it sends the data directly to the gateway by either tunneling or loose source routing. The gateway, after receiving the packet, forwards the packet to the intended destination on the wired network. Because all mobile nodes are required to register with the gateway, the gateway can check whether or not the packet' s destination is within the ad hoc network. If the destination is inside the ad hoc network, the foreign agent returns an ICMP redirect message notifying the source node to perform route discovery to find a route within the ad hoc network. As a result, the routing scheme can work efficiently with different traffic types to minimize user perceived latency.

Routing Scheme 2*:* In scenarios where a large amount of traffic is within the ad hoc network and the Internet applications are not sensitive to latency, scheme 2 can be used to reactively discover a route to the foreign agent and utilize it for Internet communication.

In this scheme, mobile nodes register with the foreign agent only when they have data to transmit to the wired net- work. Nodes do not rebroadcast the advertisement messages. Instead the foreign agent advertisement messages are unicast directly to each registered mobile node.

When a mobile node originates data traffic, it performs route discovery to locate the destination. In AODV, nodes generate a Route Request (RREQ) message for the destination. . If the correspondent node is within the ad hoc portion of the network, the source node receives a Route Reply (RREP) message indicating the route; otherwise, no RREP message is received from the other nodes within the ad hoc network.

The gateway node has a special operation upon receiving the RREQ messages. When it receives a RREQ, the foreign agent first checks whether the destination node is within the ad hoc network by determing whether that node is registered with it. If the node is registered with it, the gateway only replies to the source if it has a fresh routing entry to the des- tination. Otherwise, if the node is not registered with the for- eign agent, the foreign agent may assume the destination is on the wired network and is reachable through its wired in- terface. In this case, the foreign agent replies to

the source node with a special foreign agent (FA-RREP), indicating the route to the destination through itself.

There can be cases where the correspondent node is within the ad hoc network and is not registered with the foreign agent. In this case, the source node may receive an FA-RREP before the RREP from the actual destination. To eliminate this erroneous route, the source node may retain the route in- dicated by FA-RREP until the time interval to receive a nor- mal RREP has expired. Alternatively, before sending out the FA-RREP, the foreign agent can attempt to ping the corre- spondent node on its wired interface and ensure the destina- tion is reachable in the wired network.

Because of the special processing by the foreign agent, this scheme can adapt to different traffic by using different RREPs. If the destination is within the ad hoc network, the source will use the route indicated in the RREP from the mo- bile nodes in the network; otherwise, the source will use the route indicated by the gateway.

4. Performance Evaluation

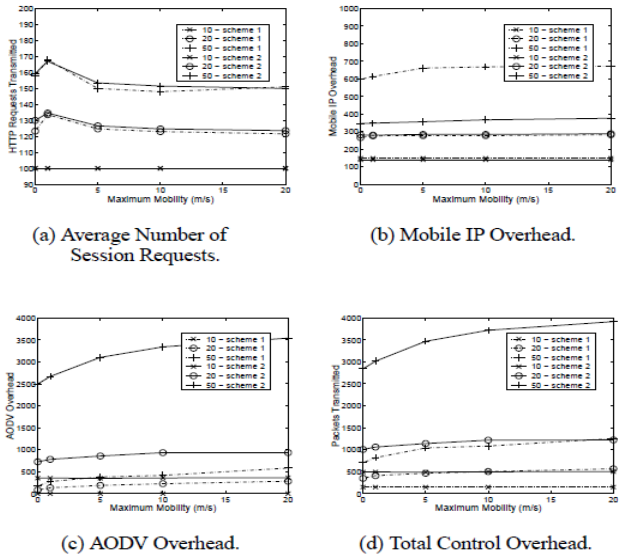
To evaluate the proposed schemes, simulations are per- formed in a wide range of scenarios. The schemes were implemented in the NS-2 simulator. Unless otherwise noted, the parameter values for Mobile IP and AODV are the same as those suggested in [4] and [6], respectively.

4.1. Experimental Setup

The simulations are evaluated in networks of 10, 20 and 50 nodes. As the number of nodes in the ad hoc network is increased, the size of the simulation area is also increased so that a consistent node density is maintained. The simulation areas are 330m x 330m, 670m x 670m and 1000m x1000m, respectively.

All mobile nodes move according to the random waypoint mobility model. Node speeds are randomly distributed between zero and some maximum, where the maximum speed varies between 0 and 20 m/s. The pause time is consistently 10 seconds. Each data point represents an average of 10 runs with the same traffic models, but different randomly generated mobility scenarios.

Figure 2: Performance Based on Web Traffic Applications.



(a) Average Number of Session Requests.

(b) Mobile IP Overhead.

(c) AODV Overhead.

(d) Total Control Overhead.

In all simulations there is a single foreign agent in the network that is connected through its wired interface to the wired network. Though the routing schemes apply when there are multiple

foreign agents, we include only results from a single foreign agent for simplicity. In the first set of simulations, web traffic with HTTP sessions is used to evaluate the performance of the two routing schemes in the first application scenario described in section I. The scenario models a large percent of traffic as Internet traffic with numerous short TCP sessions. All the source nodes are within the ad hoc network and they randomly request web pages from the correspondent nodes on the wired network.

4.2. Simulation Results

Web Traffic: In this set of simulations, web traffic is used to evaluate the performance of the two routing schemes. 100 HTTP sessions are initiated by 10 random mobile nodes in the ad hoc network within 100 seconds.

Figure 2(a) shows the average number of HTTP requests (including retransmissions) of the two schemes with different network sizes.

Table 1: Web Access Latency

Network Size	10 nodes	20 nodes	50 nodes
MIP Registration (ms)	15.8	26.3	36.2
Route Discovery (ms)	13	20.5	29.8
Web Page Retrieval Scheme 1 (ms)	29	37	54
Web Page Retrieval Scheme 2 (ms)	43	64	89

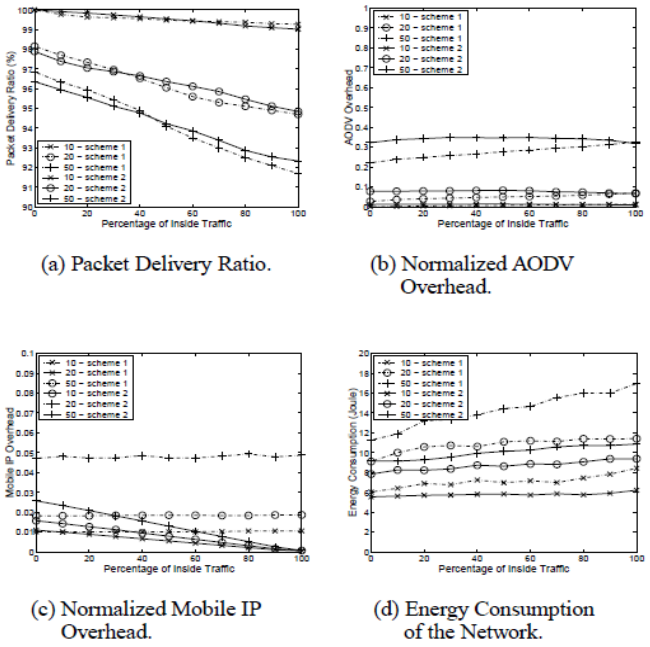
The number of transmissions in larger networks is higher because of the retransmission of requests caused by link breaks and network partitions. In figure 2(b), the Mobile IP overhead is generally higher with scheme 1 than scheme 2, due to the Agent Advertisements flooding the network. With scheme 2, only the 10 source nodes register with the foreign agent; the beacons are unicast only to these nodes. The difference is most significant with the largest net- work size. Figure 2(c) shows the AODV overhead of the two schemes. Scheme 2 has higher AODV overhead than scheme1 because a source node always issues a RREQ when it initiates a data transmission. In scheme 1, only when the link between the node and the gateway breaks, is a RREQ issued. Figure 2(d) shows the total overhead of two schemes.

In addition to these results, we also investigated the web page retrieval latency and the average routing table size during the simulation for the two routing schemes. In table I, the MIP registration time includes the time for the node to receive the agent advertisement, send out the Registration Request and receive the Registration Reply. Route discovery includes the broadcasting of the RREQ and the latency to receive RREP. These two latencies are identical in the two schemes. However, in routing scheme 2, nodes only register with a foreign agent when they want to send Internet data traffic. Hence, they have the initial Mobile IP registration latency during the web page retrieval, as well as the route discovery latency. In routing scheme 1, on the other hand, nodes proactively register with the foreign agent before they originate data traffic; hence there is no Mobile IP latency during the retrieval, nor is there a route discovery latency. As a result, the web page retrieval time for scheme 2 is higher than that of scheme 1. Further, the MIP registration latency and the route discovery latency occupy a large percentage of the retrieval time. This latency may not be tolerable when users require real-time interaction. While not shown, the simulation results also show that the routing table size of scheme 2 is nearly double of that of scheme 1, because a route discovery and route table entry is needed for each destination.

Mixed Traffic: The second set of simulations examines the performance of the two routing schemes with different percentages of Internet traffic. The percentages vary from 0% to 100%. There are 10 CBR traffic sources in the ad hoc network. The destinations are either in the wired network or

in the ad hoc network, as dictated by the percentage of Internet traffic. Other parameters in these simulations include maxi- mum node mobility of 20m/s, agent advertisement interval of 15 seconds and simulation time of 900 seconds.

Figure 3: Effects of Different Traffic Locality



(a) Packet Delivery Ratio.

(b) Normalized AODV Overhead.

(c) Normalized Mobile IP Overhead.

(d) Energy Consumption of the Network.

Figure 3(a) illustrates the packet delivery ratio with varying traffic locality. Traffic locality indicates the percentage of traffic with destinations within the ad hoc network. When the traffic locality is low, most of the traffic is Internet traffic going through the gateway; the packet delivery ratio of routing scheme 1 is slightly higher than scheme 2 because the periodic foreign agent advertisement messages help to update the route for the mobile nodes to the foreign agent.

In figure 3(b), when the traffic locality increases, the normalized AODV overhead for scheme 1 increases, while it is fairly stable for scheme 2. Normalized overhead is a ratio of the number of control packets transmitted to the number of data packets received at the destination. Normalized Mobile IP overhead remains stable for scheme 1 while it decreases linearly for scheme 2 as the locality increases, as shown in figure 3(c). In scheme 2, as the traffic locality decreases, more nodes register with the foreign agent, resulting in increased MIP overhead.

Figure 3(d) shows the total power consumed by all the mo- bile nodes. Our energy consumption model is based on [7]; energy costs are 1.6W for transmissions and 1.2W for receptions. 1.0W is consumed when idle. The network energy consumption should be proportional to the total packet trans- mission in the network. Because the data packet transmissions are the same for the two approaches, the approach with the higher control overhead should have higher power consumption.

5. Conclusions

To combat the limitations of infrastructured wireless net-works and provide Internet connectivity to ad hoc networks, hybrid networks can be deployed to support different types of applications. As wireless communication becomes increasingly prevalent, we envision hybrid ad hoc/infrastructured wireless networks becoming a viable networking solution. The Mobile IP and AODV routing protocols can work together to create a hybrid ad hoc/infrastructured network in which mobile nodes can discover multi-hop paths to foreign agents, thereby gaining Internet connectivity.

Different applications in this hybrid network may have varying requirements in terms of latency, scalability, etc. These different requirements affect the underlying routing schemes. This paper proposes two routing schemes for hybrid networks that meet different application requirements and traffic patterns. Simulation results show that with a large percentage of short web-based traffic sessions, using a gate-way as a default router results in better performance with lower latency, fewer routing table entries, and manageable control overhead. When traffic locality is high and Internet traffic is only an occasional occurrence, the reactive routing scheme results in better performance with low control over-head and higher throughput.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.310-321
http://www.europeanjournalofscientificresearch.com

NAIRU Fluctuations and Economic Growth: Evidences from Developing Countries

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Abstract

This paper investigates the influence of NAIRU (Non-Accelerating Inflation Rate of Unemployment) fluctuations on economic growth. Our study focuses on the role of time varying NAIRU in the context of economic growth. The coefficient indicating this relationship reveals the intensity of the oscillating NAIRU (as a factor that reflects the impacts of labor productivity in our model) and its influence on economic growth. First, NAIRU has been estimated using historically consistent time series for five selected countries and the roles of factors such as productivity and disguised unemployment that are considered to have impacts on NAIRU have been analyzed. Second, a model that allows for including variables in production function is used to explore the effects of fluctuating NAIRU on economic growth. The results indicate that, based on the behavior of productivity and disguised unemployment, NAIRU fluctuations are negatively correlated with economic growth.

Keywords: NAIRU Fluctuations, economic growth, NAIRU Intensity, Panel Data

1. Introduction

NAIRU fluctuations and their causes have led to the emergence of the idea that non-accelerating inflation rate of unemployment is changing because of productivity growth variation. Besides, productivity growth tends to vary over time, affecting the economic growth. Furthermore, Okun's law (1962) that is related to two types of empirical relationship between unemployment rate and real output has been developed by others to include parameters having significant impacts on the explained relationship. In this paper, we examine the impacts of productivity growth variations through NAIRU on economic growth. Ball and Mankiw (2002)[1] conclude that in the future, models will be developed to include inflation, unemployment and productivity. Productivity is a variable that has the most impact on unemployment as well as a firm's decisions about the number of workers to be employed. Timothy J. Hatton (2006) utilized long-run data of the UK to examine whether a consistent relationship exists

[1] Laurence, Ball, Mankiw, Gregory, "The NAIRU in Theory and Practice", Journal of Economic Perspectives, 2002.

between productivity growth and unemployment or not.[2] One of the factors being embedded within NAIRU as equilibrium unemployment is disguised unemployment. It is shown that the effects of fluctuating productivity are reflected in the variation of NAIRU. The production function is involved in three factors i.e. production level, labor and capital. Based upon the above-mentioned function, we have defined a three-dimension model in which NAIRU and population growth are the factors that explain labor market. Besides, NAIRU by itself indicates the influence of productivity. And the gross capital formation represents capital in the production function. This provides an opportunity to see how changes in productivity growth, through NAIRU, cause variation in economic growth.

The rest of the paper is organized as follows. The following sections briefly outline the NAIRU concept, focusing on how it is correlated with productivity. In fact, we have investigated the relationship between productivity and NAIRU. Moreover, the effects of disguised unemployment on NAIRU have been analyzed. In section 9, the role of productivity on NAIRU fluctuations is analyzed. In section 10, the specified model will be explained and we will define the coefficient of fluctuating NAIRU as NAIRU Intensity (NI). In section 11, panel data will be used to estimate the model. Finally, the results are used to assess how NAIRU fluctuations, based upon productivity variations, have impacts on economic growth. The overall conclusion is that changes in NAIRU caused by productivity variations have negatively affected economic growth.

2. NAIRU and Productivity

Productivity is the main factor when a firm decides to employ a new employee and it also plays an important role in wage bargaining, since it reflects the laborer's capability in order of increasing the production level of the firm. In fact, not only is productivity important for firms, but it also, in macroeconomic level, is a factor that defines unemployment rate as well as GDP. When labor's productivity enhances, labor adjustment to the works in the firms with changing technology will increase and finding new jobs will be easier. Besides, wages slowly adapt to productivity changes (Ball and Moffitt 2002; Ball and Mankiw 2002). So, workers in the labor force spend less time to search for a job and faster productivity growth causes lower equilibrium unemployment (Hoon and Phelps (1997)).In order to investigate the influence of productivity on NAIRU, we have estimated NAIRU drawing upon survey evidences from five selected countries based on their economic structures. We have chosen Turkey, Norway, IRAN, Pakistan and Venezuela. These countries have similar economic structures. Besides, they are dependent on one product. The main production of Iran, Norway and Venezuela is oil.Turkey and Pakistan are dependent on agricultural crops in a way that Turkey is the world's seventh producer in this field. Timothy J. Hatton (2007) investigated the way productivity growth affects NAIRU in Britain.[3] Results indicate that productivity shocks and variations in productivity growth rates have substantially contributed to the midterm ups and downs in unemployment rate over the period since 1870. Moreover, Staiger, Stock and Watson (2001) found a negative relationship between natural rate and productivity growth for US economy. We have estimated NAIRU for each of the countries through Phillips curve equation using state-space model.

$$(\pi_t - \pi_t^e) = \alpha \left(NAIRU_t - U_t\right) + \varepsilon_t \quad (1)$$

$$NAIRU_t = NAIRU_{t-1} + \eta_t \quad (2)$$

The first relationship is space equation that refers to Phillips curve and reflects the relationship between inflation gap and unemployment gap. π_t is the current inflation, π_t^e is the expected inflation, U_t is the current unemployment and $NAIRU_t$ indicates the time varying NAIRU. Second one is the state equation that involves the relationship between $NAIRU_t$ and its lag value.

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[2] J. Hatton, Timothy, "Can Productivity Growth Explain the NAIRU? Long-Run Evidence from Britain, 1871-1999", Journal of Economica.

[3] J. Hatton, Timothy, "Can Productivity Growth Explain the NAIRU? Long-Run Evidence from Britain, 1871-1999", Economica, 2007.

Table (1) reports the estimation results of the state-space model from 1981 to 2009 (for some countries, because of the lack of data the periods are shorter. The data periods for countries are respectively: Iran (1988-2008), Turkey (1987-2009), Norway (1981-2009), Venezuela (1981-2009) and Pakistan (1981-2008)).

Tabel 1: Estimation of NAIRU

countries	Unemployment Coef (α)	p_value	Average of NAIRU	Log likelihood
Iran	-6.6806	0.000	12.08514	-81.89810
Turkey	-13.28483	0.000	9.92625	-106.80901
Norway	-0.8648775	0.000	3.12513	-52.99579
Venezuella	-24.51465	0.000	10.64111	-196.72754
Pakistan	-2.576476	0.000	4.58516	-83.23528

According to the results, all of the unemployment coefficients are negative and significant, reflecting that disinflation will result in unemployment. Average of NAIRU is the ordinary average of estimated NAIRU for each country that shows Iran has the maximum and Norway with minimum mean. An important question that comes to mind is what factors affect NAIRU and cause it's fluctuations over time? There can be numerous factors that make NAIRU change such as productivity fluctuations, lack of important investment in infrastructures, severe deficiency in educational system and demographic changes. As we mainly aim at finding out how NAIRU fluctuations, based on productivity variations, have affected economic growth, we have investigated the influences of Labor Productivity, Per Person employed, on NAIRU. As Follows, a simple regression is estimated to find out the sign of relationship between these two variables:

$$NAIRU_t = \beta_0 + \beta_1 \left(labor\ productivity \right) + \varepsilon_t \tag{3}$$

Table (2) presents regression with NAIRU in each country as a dependent variable and labor productivity as an independent variable:

Tabel 2: Relationship between NAIRU and labor productivity

countries	β0	Productivity Coef (β1)	p-value	R2	F-statistic
Iran	26.41195	-0.571766	0.0001	0.54259	22.53822
Turkey	11.86388	-0.067257	0.1131	0.115193	2.733988
Norway	21.38584	-0.213758	0.0000	0.878049	194.4007
Pakistan	-1.443287	0.878883	0.0001	0.438277	20.28612
Venezuela	29.36869	-0.6381	0.0001	0.453875	22.4392

The fall in productivity in Iran, Turkey, Norway and Venezuela is associated with increasing NAIRU; but, the coefficient is negative. All of the coefficients are significant in %1 unless for turkey in %11. To delineate these relationships more clearly for each country, we have plotted the NAIRU against the labor productivity:

Figure 1: NAIRU and labor productivity

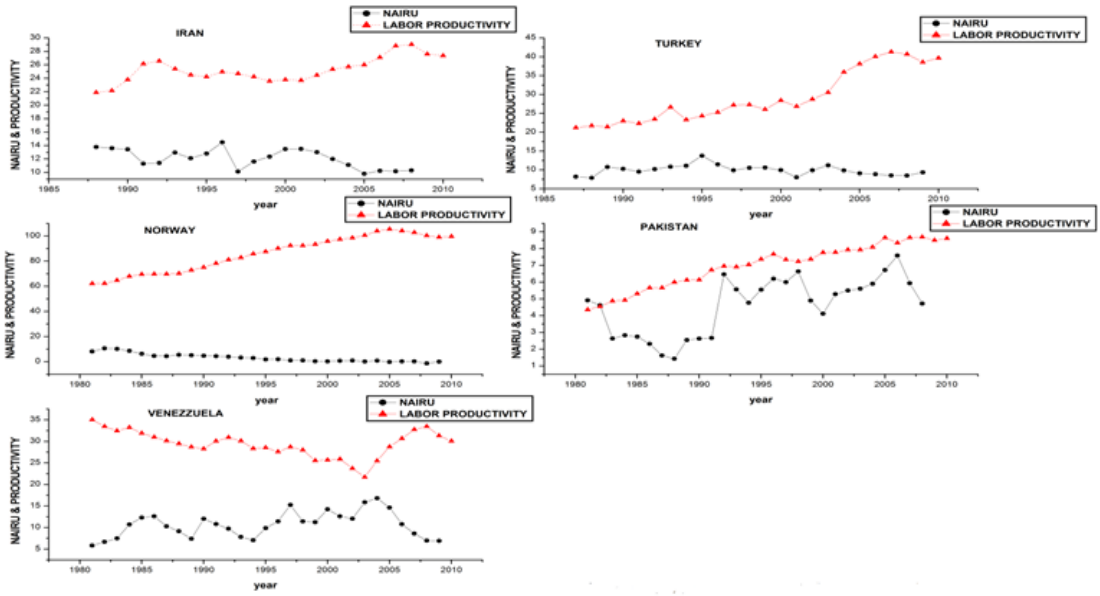


Figure (1) illustrates the changes in the NAIRU against productivity. In each country, the trend of NAIRU according to the above-drawn figure is explained and their interaction relationship is presented.

3. NAIRU Trend in IRAN

As table (2) reports, one percent decrease in productivity will result in 0.57 percent rise in NAIRU. From 1988 to 1992, labor productivity has increased while NAIRU has fallen down. In 1988, NAIRU and productivity have been 13.79763 and 21.895 respectively. In 1992, productivity increased to 26.581 and made NAIRU to decline to 11.41876. Over this period, the war between Iran and Iraq had just ended; thus, capital stocks and goods used during the war, had been transferred to production sectors especially agriculture. From 1993 to 1996, NAIRU reached 14.49131 that is the maximum rate during the period of study. Besides, productivity has declined to 24.965 in 1996 compared with 25.403 in 1993. Moreover, from 1994 to 1995, labor participation rate as a percentage of the total population has declined from 43.2 to 42.7. This period coincided with liberalization policies of government that made the inflation rate to rise to its maximum i.e. 49.65 percent in 1995.

Over the period 1997 to 2001, productivity has boosted; likewise, NAIRU kept rising. During this period, with regard to failure of liberalization policies caused by deep-rooted influences of war, the control policies became the main concern for policy-makers in order to prevent the inflationary pressure. The labor productivity reached 23.689 and NAIRU that experienced a fall to 10.1395 in 1997, increased to 13.5097 in 2001.

Over the years 2002 to 2008, productivity enhanced and NAIRU had collapsed in a way that in 2002, NAIRU and productivity were at 13.021 and 24.475 and reached 10.31 and 29.04 in 2008 respectively. The minimum NAIRU domain analysis occurred in 2005 when it was equal to 9.801. Moreover, gross capital formation has reached 48.21 billion dollars in 2005 from 32.63 billion dollars in 2001 that played an important role in expanding production level; hence, the equilibrium unemployment went downward. One important thing that is to be considered is the increasing labor force from 20.7 million in 2002 to 24.3 million in 2005. The labor participation rate was 44.7 percent in 2002 increasing to 47.2 in 2005. After 2005 (the minimum NAIRU), NAIRU has increased a little to 10.25 in 2006 and to 10.31 in 2008. The important point in this period is the decrease of foreign direct

investment as a percentage of GDP from .73% to .47% (that can be considered as one of the reasons that productivity declined in 2009 and 2010) and falling in labor participation rate from 46.2 to 43.2.

4. NAIRU Trend in Norway

In 1981, NAIRU was 8.2 then reached 10.19 in 1983. During the mentioned period, productivity enhanced as well; besides, foreign direct investment declined from 1.06% to 0.54%. It should also be noted that in 1981 and 1982, productivity was somewhat fixed about 62, yet increased to 64.6 in 1983 that may have affected NAIRU and made it decrease to 8.56 in 1984.

From 1984 till 1987, NAIRU kept the decreasing trend and reached 4.42 in 1987. On the other side, productivity increased to 69.81. Moreover, foreign direct investment as the percentage of GDP was 0.29 in 1984 and amounted to 0.20 in 1987.

Over the years from 1988 to 2000, with regard to an increase in NAIRU up to 5.52, it reached to .19 in 2000 that is coincident with rising in productivity. Productivity had become 95.9 in 2000 from 70.18 in 1988; furthermore, during the mentioned period, foreign direct investment increased to 4.13. Likewise, labor participation rate rose up to 66.099 percent. Afterward, NAIRU has declined more and reached a negative sum in 2005 and 2008, respectively -.17 and -1.34. Productivity maintained its increasing trend and was equal to 105.5 in 2005. From 2001 to 2009, foreign direct investment had a low rate being approximately 1.70 percent and ICT goods import as the percentage of total goods imports has decreased from 9.86 in 2000 to 7.67 in 2009.

5. NAIRU Trend in Turkey

From 1987 to 1995, though NAIRU had a rising trend; yet, it had somewhat a negative point to point relationship with productivity. Also, foreign direct investment had a low share in GDP which its average was 0.44% and labor participation rate had declined from 57.9 percent in 1990 to 54.5 percent in 1995. From 1996 to 2000, NAIRU has collapsed and reached 8.02 percent in 2001 from 11.45 in 1996. Besides, labor productivity has an incremented trend that caused labor productivity to become 28.42 reflecting about three units increase from its amount in 1996 that was 25.29. Afterwards, from 2001 to 2009, despite NAIRU had a stable value and had fluctuated around 9 percent; but, it had a point to point negative relationship with productivity.

6. NIARU Trend in Pakistan

From 1981 to 1988, NAIRU had fallen down from 4.91 in 1981 to 1.42 in 1988 and productivity had increased. In 1989, NAIRU jumped up to 2.54 and till 1991, it had somewhat a fixed value. Then it had changed again to 6.46 in 1992; while, productivity was oscillating from 6.12 to 6.95. Foreign direct investment increased a little but the jobs created aided by that couldn't prevent NAIRU from increasing. Then, NAIRU maintained its fluctuations around 5.2 that were positively related to productivity as a whole. In this period, ICT goods imports enhanced that can lead to the increasing trend of productivity which may have less labor been used in production process that makes the high level of NAIRU expectable.

7. NAIRU Trend in Venezuela

From 1981 to 1986, productivity had declined and NAIRU had increased. Afterwards, NAIRU had fluctuated a little till 1997 when it was 15, and then it fell down; besides, productivity had fluctuated as opposed to NAIRU indicating when NAIRU had increased it decreased vice versa.

8. What is Disguised Unemployment Effect?

Disguised unemployment exists where part of the labor force is either left jobless or is working in a redundantly and people do not have productive full-time employment, but are not counted in official unemployment statistics. According to a study by the United Nations, the form of human resources waste is sometimes called 'concealed' or 'disguised' unemployment, and may be created by any of the conditions producing total unemployment, including structural maladjustments, cyclical fluctuations, or persistent deficiency of general demand for labor.[4] An economy demonstrates disguised unemployment where productivity is low and where too many workers are filling too few jobs.

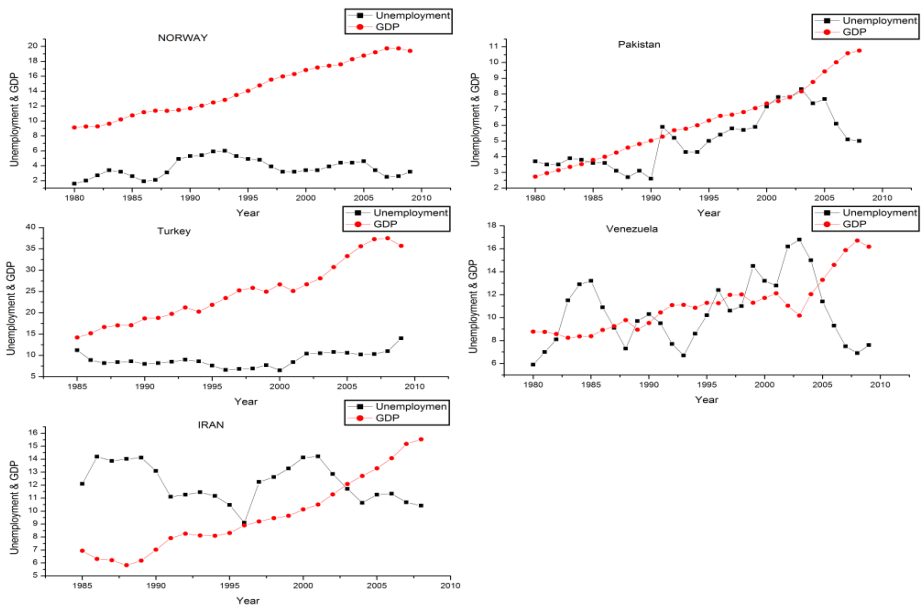
It exists frequently in developing countries whose large populations produce a surplus in the labor force. Disguised unemployment is characterized by low productivity and frequently accompanies informal labor markets and agricultural labor markets, which can absorb substantial quantities of labor.

The disguised unemployment may be realized in the following forms:

- People on sickness / disability benefits (but, would be able to do some jobs)
- People doing part-time work.
- People forced to go into early retirement and redundancy
- Disguised unemployment could also include people doing jobs that are completely unproductive, i.e. they get paid but they don't have a job.

As variation in disguised unemployment can affect the equilibrium unemployment; so, in order to investigate the disguised unemployment, we have plotted unemployment rate against the GDP indicating when unemployment is changing positively or negatively what the behavior of GDP is and in which direction it is varying. The results for selected countries in this study can be seen in Figure (2):

Figure 2: Unemployment & GDP



In periods when unemployment decreases but GDP doesn't change, it indicates that more labors in the production process don't have impact on the output level and this has led to the disguised unemployment that can be for many reasons such as low productivity, low level of wages in relation to inflation that hindered workers from working full-time. In fact, some workers are employed but for the

[4] The Determinants and Consequences of Population Trends, United Nations, Dept. of Social Affairs, Population Division, Population Studies No. 17, 1953, pp.249-250.

workplace atmosphere conditions don't have motivation to work full-time; hence, with rising employment, the increase in production is not considerable.[5]

We shall assume that given the condition of the labor market, employers of labor force try to maximize their utility function. Dipak Mazumdar (1959)[6] implied that we admit the possibility of variation of workers' efficiency with the wages paid to him.

One factor that has undeniable impact on the rate of disguised unemployment is the way worker's productivity is compensated by wages. This is based upon the fact that workers decide about work hours that determines disguised unemployment. In fact, each person has a threshold level that is dependent on productivity compensation.

Based on the above-mentioned explanation the worker's utility function can be shown as bellow:

$$U_W = f\left(I_W, L_W, L_{OW}\right) \tag{4}$$

In which U_W is a worker's utility that is a function of worker's income (I_W), workplace leisure (L_W) and out workplace leisure (L_{OW}). Labor's leisure time contains both leisure time in the workplace that is a function of how productivity is compensated or how the level of wages is related to the productivity and outwork leisure time is a function of income level or generally speaking worker's wealth. Moreover, workplace leisure time is positively correlated with disguised unemployment in a firm; because, when the compensating system is not efficient and wages are not proportionate to productivity, more workers (specially more expert workers) have the tendency not to work fully; hence, disguised unemployment is going to increase apart from decreasing productivity. The explanation above can be reflected in a mathematical system as bellow:

$$Worker's\ Leisure\ time = L_W + L_{OW} \tag{5}$$

$$L_W = f\left(how\ productivity\ is\ compensated\right) \tag{6}$$

$$L_{OW} = f\left(worker's\ wealth\right),\ f'>0 \tag{7}$$

$$Disguised\ Unemployment = f\left(L_W\right), f'>0 \tag{8}$$

According to the equation (6),it is specified that workplace leisure time is a function of "how productivity is compensated" that can be investigated through dividing workers of a firm to several groups based on their capability and human wealth, and then estimate how wages are correlated with productivity in each group through estimating the following regression:

$$Wage = f\left(productivity\right) \tag{9}$$

If in a group with a high average level of productivity, the estimated coefficient is greater, that means changing in productivity in this group is leading to more changes in wages and productivities are compensated efficiently. The last equation indicates that when workplace leisure time is increased, it makes the Disguised Unemployment rise.

Suppose that we have n workers in the macroeconomic level and workplace leisure time for workers are: L_{W1}, L_{W2}, L_{W3},…,L_{Wn}. Besides, assume each worker is working H hours a day, then disguised unemployment for each worker can respectively be: $\frac{L_{W1}}{H}, \frac{L_{W2}}{H}, \frac{L_{W3}}{H}, \ldots, \frac{L_{Wn}}{H}$. So, Disguised Unemployment in a macro-level can be the average of workers' disguised unemployment that is:

$$Disguised\ Unemployment = \frac{\frac{L_{W1}}{H} + \frac{L_{W2}}{H} + \frac{L_{W3}}{H} + \ldots + \frac{L_{Wn}}{H}}{n} \tag{10}$$

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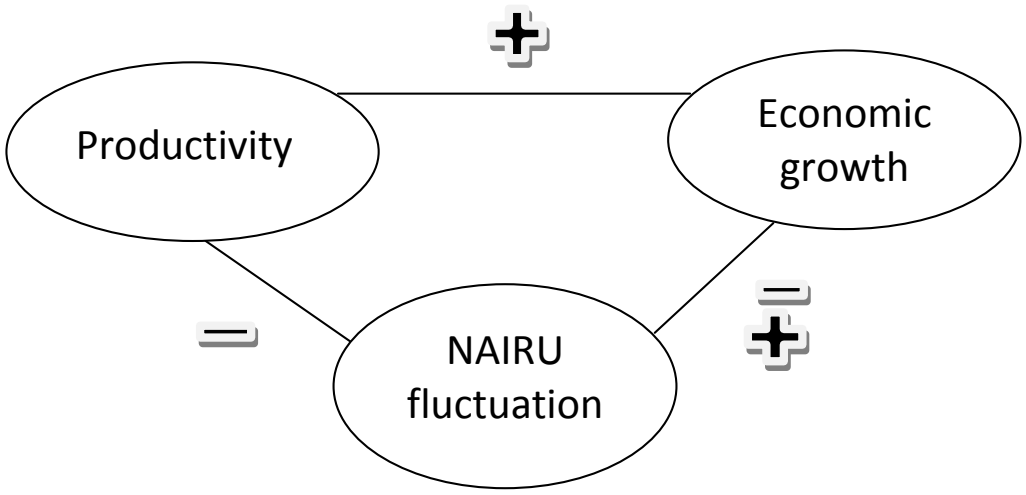
[5] YASUOKI TAKAGI , SURPLUS LABOR AND DISGUISED UNEMPLOYMENT, Oxford Economic Papers, Vol. 30, No. 3 (Nov., 1987), pp. 447-457, Oxford University Press.

[6] DipakMazumdar, The Marginal Productivity Theory of Wages and Disguised Unemployment , The Review of Economic Studies, vol 1.26, No.3 (Jun., 1959), pp. 190-197, Oxford University Press.

Changes in Disguised Unemployment have effects on equilibrium unemployment (NAIRU) specially in under-developing countries, where wages are not based on productivity and experts like to immigrate to developing countries to gain more that leads to more brain drain in those countries. In countries dependent on one resource revenue (which cause the economic relationship become based on rent in the work place), minimum work hours are necessary in order to show attendance in work place and as worker's compensation is not based on productivity and all workers have the same and determined wages, so they prefer to do minimum work and in order to maximize their utility function, they have work leisure times. In fact, one of the important problems of developing countries, especially countries relying on one resource is the mentioned work leisure time that leads to the increase in surplus labor and also disguised unemployment which leads to high level of NAIRU in these countries.

9. Productivity and NAIRU Fluctuation

In this section, we aim at providing a model with a particular attention to the possible role of productivity on NAIRU fluctuations. Increases in labor productivity make the production level rise vice versa. According to the discussion above, productivity growth is negatively related to NAIRU, while it has positive impacts on the production level seen as follows:



The main concern of this paper is to determine how fluctuating NAIRU changes economic growth. In fact, changes in productivity are from among the main factors in labor market that have important effects in the demand for labor and probably if the market is clear highly qualified labor force are paid high wages. On the other hand, Irving Fisher (1933) mentioned that the process of deflation is like an increase in the real rate of interests and is reducing demand for goods and services. Besides, Laurence Ball (1997) in his paper concludes that disinflation raises unemployment not only in the short-run, but also in the long-run; moreover, he argues that, if tight monetary policy has raised NAIRU, perhaps loose policy can reduce it. In inflationary situation, NAIRU is higher than the actual rate. This leads to more flexibility of nominal wages that may be ineffectual or even counterproductive.(James Tobin, 1997)[7]. Notwithstanding, in countries like IRAN there are structural deficiencies and being a highly qualified worker is not necessarily accompanied with high wages; because, there is a lack of active private sector and high inflation level hinders investment decisions making mongers' activities the most profitable. Though in such countries being productive is not connected with finding a job, yet it increases the chance of getting it. High productivity laborer has more chance to be accepted in a position; hence, it can be expected that enhancing the level of

[7] "supply constraints on employment and output: NAIRU versus natural rate", COWLES FOUNDATION FOR RESEARCH IN ECONOMICS AT YALE UNIVERSITY, James Tobin, 1997.

productivity through technology, increasing the matchmaking of workers to the suggested. Moreover, fluctuation in the productivity can make NAIRU fluctuate. Ball and Mankiw argue that "actual feature of the New Economy of the late 1990s was arisen in the growth rate of labor productivity. A key fact about the productivity acceleration is that it started in mid-1990s, about the same time that researchers started detecting a decline in NAIRU. This coincidence suggests a link between the two phenomena". In the upcoming section, we define the model framework and examine how fluctuating NAIRU has changed economic growth in nominated countries and introduce the coefficient that shows the severity of relationship as "NAIRU Intensity" (NI).

10. Model Framework

Based on the discussion above, we define a model in which NAIRU fluctuation explains economic growth.

Labor and the capital are the factors that in micro-level determine a firm's production and in macro-environment, the GNP. In fact, according to the economics literature, these factors are essential for producing an output and equilibrium between demand and supply of them defines the equilibrium production level.

According to the Neoclassic growth theory, two production factors are capital and labor:

$$Y_{it} = f\left(K_{it}, L_{it}\right) \tag{11}$$

Y_{it} is the production level of country i.in time t, K_{it} is capital of country i.in time t and L_{it} is labors who take part in production of country i.in time t. L represents the workers who have participation in production that is affected by NAIRU. On the other side, increases or decreases in NAIRU have changed equilibrium labor as well as the production. If L_A shows accessible labor that has participation in production, the following relationship can be shown:

$$L_A = f\left(L_{NAIRU}\right), f' < 0 \tag{12}$$

L_{NAIRU} are the labors who in the unemployment connected with NAIRU don't have participation in the production which has negative connection with the accessible labor. In fact, increases in NAIRU raise the L_{NAIRU} and decreases the production.

We call the model which will be used to estimate NI "Three sided model"; because, it includes agents representing labor market situation, capital and production. NAIRU fluctuations and population growth indicate the labor market status. NAIRU fluctuations indicate changes in labor productivity and population growth shows the potential accessible labor in the future. Domestic gross capital formation growth is the cause of capital and production variations in the model which is reflected by economic growth.

The important point is that this three-pronged model depends on research objectives and economic situation, other variables such as effective labor, labor force and employment can be used as representatives of labor market.

The model can be shown as:

$$Y_{it} = f\left(CAP_{it}, NAIRU_{it}, POP_{it}\right) \tag{13}$$

Y_{it} indicates the production of country i in time t, CAP_{it} is the domestic gross capital formation of country i in time t, $NAIRU_{it}$ is the NAIRU of country i in time t and $POP_{it}$is the population of country i in time t.

If we assume that production function is in the Cobb-Duglas form, it can be shown as:

$$Y_{it} = A.CAP_{it}^{\alpha_1}.NAIRU_{it}^{\alpha_2}.POP_{it}^{\alpha_3} \tag{14}$$

Written in logarithm, we have:

$$LOG\left(Y_{it}\right) = LOG\left(A\right) + \alpha_1 LOG\left(CAP_{it}\right) + \alpha_2 LOG\left(NAIRU_{it}\right) + \alpha_3 LOG\left(POP_{it}\right) \tag{15}$$

In order to indicate NAIRU fluctuations, we can write the differentiated form of equation above as:

$$dLOG(Y_{it}) = dLOG(A) + \alpha_1 dLOG(CAP_{it}) + \alpha_2 dLOG(NAIRU_{it}) + \alpha_3 dLOG(POP_{it}) \quad (16)$$

In fact, $dLOG(Y_{it})$ represents economic growth and coefficients reflect elasticity of each variable:

$$GDP\ Growth_{it} = dLOG(A) + \alpha_1 dLOG(CAP_{it}) + \alpha_2 dLOG(NAIRU_{it}) + \alpha_3 dLOG(POP_{it}) + \varepsilon_{it} \quad (17)$$

GDP $Growth_{it}$ is the economic growth for country i in time t, dLOG(A) is equal to zero, $dLOG(CAP_{it})$ is the gross capital formation growth for country i in time t, $dLOG(NAIRU_{it})$ is the NAIRU fluctuationsfor country i in time t,$dLOG(POP_{it})$ is the population growth for country i in time t and ε_{it} is the disturbance error. As to the last equation, it can be seen that the intercept which was a factor for productivity effects is equal to zero and it arises a question about which variable is involved in productivity changes? According to the economic literature of NAIRU and productivity, these two variables have negative relationship. Yet in our model, variations in the productivity are reflected by NAIRU fluctuations that indicate increases in productivity decrease NAIRU and its fluctuations.

In this model,α_2 is NAIRU Intensity which is defined as "a coefficient that reflects the severity of NAIRU fluctuations effects on economic growth". Furthermore, NI indicates the sensitivity of economic growth to NAIRU fluctuations.

11. Estimation Results

In this section, we have estimated the model specified above using panel data in order to achieve the NI in the countries under study. According to Hausman test, the above-mentioned model has been estimated with random effects that the results are shown in the following table:

Table 3: Panel estimation results

Variables	Results		
	Coefficients	t-statistic	prob
C	2.61637	4.377087	0.0001
dlog(NAIRU)	-0.962412	-2.076487	0.0442
dlog(CAP)	14.39905	10.03668	0
dlog(pop)	73.47675	2.044473	0.0474
R2	0.571785		
F-statistic	18.24877		

The intercept term that reflects differences among countries is significant; besides, according to the results, the NAIRU Intensity is estimated -0.96 which means one percent increase in NAIRU fluctuations can lead to 0.96 percent fall in GDP growth. Variation in NAIRU is equal to unstable Non-Accelerating Inflation Rate of Unemployment that has negative impact on production and consequently economic growth. On the other side, as a result of variation in NAIRU either up or down, more workers will experience unemployment. These workers lose human capital, become less attractive to employers and reduce their job-finding activities as they become accustomed to being unemployed (Layard, Nickell and Jackman, 1991). Thus, their productivity and capability as well as enthusiasm to work perfectly will change,making GDP growth decrease.

If we want to have steady-state economic growth, the equilibrium unemployment will be stable. On the other side, according to our findings, fluctuations of NAIRU as a factor of labor market in our model will decline economic growth in two ways. At first, as the unemployment equilibrium is fluctuating over time, we can result that there is not a convergence between supply side and demand

side in the labor market. This can be resulted from structural characteristics of labor market as well as monetary and fiscal policies. If policies are not stable, upon accepting that there is not money illusion in the labor market, any changes in policies will result in inflation expectation changes; hence, decision-makers' decisions in the labor market vary over time and as a result, equilibrium keeps changing. Second, as the content of NAIRU indicates, it is an equilibrium rate of unemployment which is consistent with a rate of inflation; therefore, NAIRU fluctuations indicate that the non-accelerating inflation rate of unemployment alters every year implying that the economy doesn't have a stable rate of inflation (in which there is no acceleration) and if the policy-makers attempt to achieve this point, it will be very hard because of the changing. So, uncertainty in policies worsens the undulation of inflation and consequently inflation uncertainty will increase. Inflation uncertainty increases the risk of investment as well as the production rate.

Fluctuations in NAIRU originates from instability in labor market, unpredictable government's decisions and central bank policies as to decreasing inflation (Ball) that raise uncertainty in both production and labor market as well as interrupting investment decisions. Hence, it has negative effects on GDP growth confirmed by estimation results. Technological innovation (that increases the labor productivity as well as the value of laborer's to the firm (Jiri Slacalek, 2004)) and education increase the worker's effectiveness and can stabilize NAIRU resulting into lower fluctuations. Moreover, productivity shocks cause variations in disguised unemployment; thus, it can change the unemployment equilibrium (NAIRU).Furthermore, as it is expected, fixed capital and population growth have positive effects on economic growth.

12. Results and Discussion

There have been extension studies regarding unemployment (especially NAIRU) and productivity effects on its change. But the effects associated to the time varying NAIRU or fluctuations in NAIRU in growth context is somehow ambiguous that in this paper it is tried to be explained. The role of fluctuations in NAIRU and the resulted effects on economic growth have been investigated for five selected countries. Estimation of NAIRU reflects a variation in the Non-Accelerating Inflation Rate of Unemployment in all countries under study. To examine how labor productivity explains NAIRU, we have estimated a simple regression that came to the result that labor productivity is negatively related to NAIRU in all countries but Pakistan. Other determinant being related to the structure of labor market is disguised unemployment that depends on how productivity is compensated.

In order to understand how fluctuations in NAIRU change economic growth, simple three-dimension model has been specified and NAIRU Intensity (NI) which is the coefficient of NAIRU in our model has been estimated based on that. According to the panel estimation results, NI has been shown to be negative implying "NAIRU fluctuations have negative effects on economic growth". Furthermore, gross capital formation and population growth have been shown to have positive impacts on economic growth.

In future studies, models may include disguised unemployment as a factor that can change with productivity compensation in an organization to explain NAIRU behaviors.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.322-326
http://www.europeanjournalofscientificresearch.com

Measurement of Radon Gas Concentration in Bentonite Samples by using Nuclear Track Detector (CR-39)

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Abstract

In the present work, we have measured the radon gas concentration in four bentonite samples different in origin(Iraq, Al-Saudi Arabia, Iran, India), by using alpha-emitters registrations which are emitted from radon gas in (CR-39) nuclear track detector.

The obtained results have shown that the highest average radon gas concentration in bentonite samples was found in Al-Saudi Arabia sample, which was (36.75 Bq/m^3), while the lowest average radon gas concentration in bentonite samples was found in Iran sample, which was (9.17 Bq/m^3) .The present results show that the radon gas concentration in all bentonite samples is below the allowed limit from International Commission of Radiation Protection (ICRP) agency.

Keywords: Bentonite, Radon Gas, CR-39

1. Introduction

Bentonite means a mineral solid found in (1890) in Benton area. It has a soft grains and brown color yellowish. Bentonite is a clay generated frequently from the alteration of volcanic ash, consisting predominantly of smectite minerals, usually montmorillonite. Other smectite group minerals include hectorite, saponite, beidelite, and nontronite (Grim, 1978).

The theoretical formula for the structure give above is $(OH)_4Si_8Al_4O_{20}$ n (interlayer) H_2O. Theoretical composition without the inter layer material is SiO_2 66.7% , Al_2O_3 28.3% , H_2O 5%. The chemical formula for the montmorillonite group is $(Al, Mg)_2 (OH)_2 (Al , Si)_4 O_{10}$ (Grim, 1962).

The bentonite molecular contains of three layers, the first one is from aluminum Octafaces, it's found between two layers of silica. The bentonite molecular has a negative charge surrounded by positive ions, and if this positive ions is sodium ions it could be called sodium montmorillonite, and if it is calcium ions it would called calcium montmorillonite (Abawee, 2009).

Because of the weakness connector between the bentonite molecular water molecules penetrate between the layers, creating gelatinous and viscous fluid. This SO-called interlayer swelling or crystalline swelling leads to, at most, a doubling of the volume of the dry clay (Ali, 2007).

Bentonite is used in different properties of smectite group minerals. It used as following (Grim, 1978; Grim, 1962; Ali, 2007):

Purification plant oil, purification mineral water, absorption of water and aromatics, absorption of heavy elements, industry of crucible sand for alloys, pellitization, field of medicine and pharmalogy, cosmetics, filler in painting, paper and rubber, anti insects and grass, smoothing the skin and hair for more than a half century. After that has been changed by shampoo. Although there is a percentage of bentonite based sodium used in shampoo manufacturing, used in paste production which used for skin and smoothing.

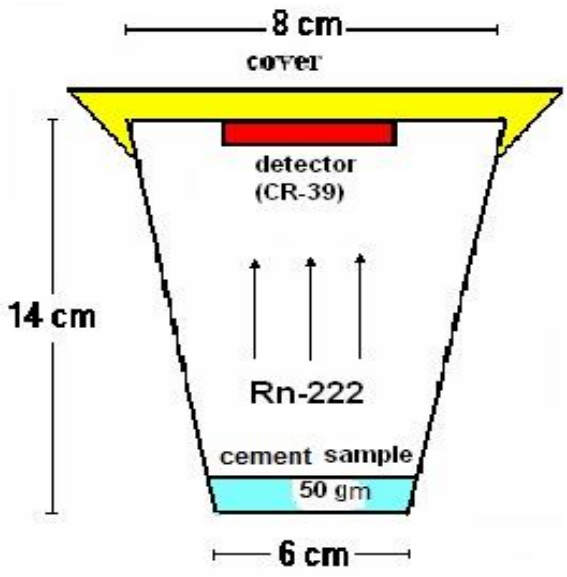
Because the possible harmful side effect of bentonite clays which was available in the local markets, one of them was Iraqi, and the others from different countries (Al-Saudi Arabia, Iran, India), so we studied the nature of radioactive which is emitted from these clays in order to assure their safety.

2. Experimental Part

The determination of the concentrations of Alpha particles emitted from radon gas in bentonite samples were performed by using the nuclear track detector (CR-39) of thickness 250 μm and area of about 1×1 cm^2.

The radon gas concentration in bentonite samples was obtained by using the sealed-cup technique as shown in Fig. (1).

Figure 1: A schematic diagram of the sealed-cup technique in bentonite sample.



After the irradiation time (60 days), the track detectors (CR-39) were etched in 6.25 N of NaOH solution at temperature of 70 ^oC for 5 hr, and the tracks density were recorded using an optical microscope type (ALTAY BIO-1007) with magnification of 400X. The density of the tracks (ρ) in the samples were calculated according to relation (1) (Amalds et al, 1989):

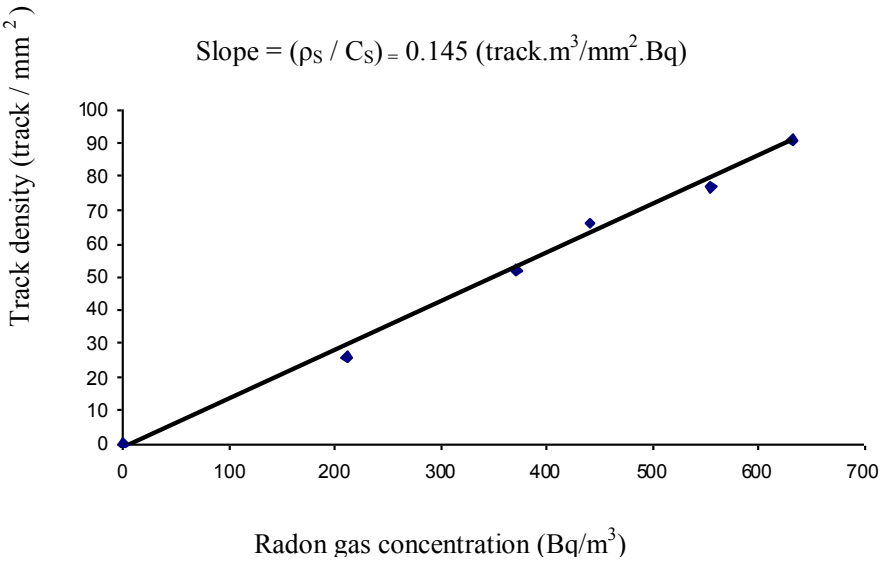
$$Track\ density\ (\rho) = \frac{Average\ number\ of\ total\ pits\ (tracks)}{Area\ of\ field\ view} \quad (1)$$

The radon gas concentration in bentonite samples were obtained by the comparison between track densities registered on the detectors of the samples and that of the standard bentonite samples which are shown in Fig.(2), using the relation(2) (Durrani and Bull, 1987):

$$C_X = \rho_X . (C_S / \rho_S) \quad (2)$$

Where : C_X : alpha particles concentration in the unknown sample.
C_S : alpha particles concentration in the standard sample.
ρ_X : track density of the unknown sample (track/mm^2).
ρ_S : track density of the standard sample (track/mm^2).

Figure 2: Relation of radon gas concentration and track density in standard samples (**Mansour, 2010)**.



3. Results and Discussion

Our present investigation is based on the study of 4 samples from different origin of bentonite which was available. It can be found that the radon gas concentrations by using alpha-emitters registrations which are emitted form radon gas in nuclear track detector (CR-39).

Table (1) represent the radon gas concentrations for bentonite samples in different countries. It can be noticed that, the highest average radon gas concentration in bentonite samples was found in Al-Saudi Arabia bentonite sample, which was (36.75 Bq/m^3), while the lowest average radon gas concentration in bentonite samples was found in Iran sample, which was (9.17 Bq/m^3).

It might be mentioned that, thoron gas is an alpha emitter which is also present in soil and the other investigated materials. However, the average diffusion distance of thoron gas is very small compared to that of radon (Saad, 1998).

The present results indicate that the radon gas concentrations in all bentonite samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency which is (200 Bq/m^3) in soil sample (Pzrbylowicz and Skowronski, 1977).

The raw material which is used in production of some bentonites is containing various amounts of natural radioactive elements. During processing this material, owing to chemical properties of Radium, practically all (Ra^{226}) gets incorporated into bentonite and remains in disequilibrium status when it compared to radioactivity levels contained in the raw material. Most of the materials are considered waste and are stockpiled or discharged into the aquatic environment (UNSCEAR, 2000). Potential issues of concern resulting from waste disposal are its environmental impacts; possible increases in radio- nuclides in soils or in groundwater and consequential ingestion by humans through exposure routes such as drinking water and food chain (Laich, 1991). Once, deposited in bone tissue, (Ra^{226}) has a high potential for causing biological damage through continuous irradiation of human skeleton over many years and may induce bone sarcoma (Marovic and Sencar, 1995).

The natural radionuclides of concern are mainly Potassium, Uranium, and Thorium, and the radio-nuclides that are created as their radioactive decay chains. Emanation of Radon gas (e.g. Rn^{222}

and Rn^{220} of lifetimes about 3.8 day and 55.6 s respectively) into air occurs as a product of uranium (U^{238}) and thorium (Th^{232}) decay chains, respectively. The short lived decay products of radon are responsible for most of the hazards by inhalation. The hazard of Radon comes from its radioactive progeny, which use their physical properties to spread or attach like aerosols do, trapped in the lung and depositing their alpha-particle energies in the tissue, producing higher ionization density than beta particles or gamma-rays. Lung cancer, skin cancer, and kidney diseases are the health effects attributed to inhalation of radon-decay products (Kumar et al, 1986). The sources of radon gas are the building materials and its components, ground water, and soil (Ahmad et al, 1998). The radiological impact from the above nuclides is due to radiation exposure of the body by the gamma rays and irradiation of the lung tissues from inhalation of Radon and its progeny (Papastefanou et al, 1983). From the natural risk point of view, it is necessary to know the dose limits of public exposures and to measure the natural environmental radiation level provided by ground, air, water, foods, building interiors, etc., for the estimation of the exposures to natural radiation sources. Low level gamma-ray spectrometry is suitable for both qualitative and quantitative determinations of gamma-ray emitting nuclides in the environment (IAEA, 1989).

Table 1: Radon gas concentration for Bentonite samples from different countries

No. of sample	Origin of Bentonite		Samples			
			1	2	3	Mean
1	Iraq	Radon Concentration (Bq/m^3)	13.8	13.8	20.7	16.06
		Track density (Track $.mm^{-2}$)	2	2	3	2.33
2	Al-Saudi Arabia	Radon Concentration (Bq/m^3)	27.6	55.17	27.6	36.75
		Track density (Track $.mm^{-2}$)	4	8	4	5.33
3	Iran	Radon Concentration (Bq/m^3)	6.9	6.9	13.8	9.17
		Track density (Track $.mm^{-2}$)	1	1	2	1.33
4	India	Radon Concentration (Bq/m^3)	13.8	6.9	13.8	11.44
		Track density (Track $.mm^{-2}$)	2	1	2	1.66

4. Conclusions

From the present work, it can be concluded that the highest average radon gas concentration in bentonite samples was found in Al-Saudi Arabia sample, which was (36.75 Bq/m^3), while the lowest average radon gas concentration in bentonite samples was found in Iran sample, which was (9.17 Bq/m^3). The present results show that the radon gas concentration in all bentonite samples are below the allowed limit from International Commission of Radiation Protection (ICRP) agency.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.327-338
http://www.europeanjournalofscientificresearch.com

Development of a Treatment Plant for Flax Retting Wastewater

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Abstract

Based on the experimentation on batch and continuous type systems, this work presents the development of an integrated plant for treatment of actual flax retting wastewater generated from Tanta Company for Oil and Flax in Egypt. The Company produces high concentrated organic polluting and odorous effluent discharged into an agricultural drain course called "Roh Mahal "which is not conforming to environmental requirements. The proposed configuration comprises combined anaerobic and aerobic processes in series producing partially treated water, which is then distributed into three lines: The first is reused by recycling to the flax retting chambers, the second to be used in floor cleanings while the third part is further treated by a nanofiltration unit where the permeate is also recycled to the retting process, and thus, Zero discharge is achieved. Process design for 440 m^3/day wastewater is carried out using previous results of the monitoring of a pilot-scale plant comprising of an UASB reactor followed by an activated sludge system. Preliminary economic evaluation is then performed using data from local market, supplier offer and literature survey.

Keywords: Flax retting, Wastewater treatment, Design, Cost estimation

Introduction

Flax is a highly valuable annual plant used for textiles (linen) and for technical applications, such as specialty papers, composites and insulating materials. Flax grows up to 120 cm in height. When grown for fiber, flax is sown densely to prevent branching and promote a taller plant. These long fibers are processed in the textile industry to 0.55 ton of yarn and are used to produce fine yarns (wet spun) and strong threads [Jua´rez, et al.,2011]. In the plant the fibers are glued together strongly by polysaccharides and lignins and are embedded inside the stem in a woody matrix. To obtain the useful fibers from the plant, a retting step is required. Retting is normally done by microorganisms, but the term retting has also been used indistinctly for the chemical degradation of the pectic substances. During retting, the binding pectic substances by which the fiber bundles are attached to the surrounding bark matrix and the woody core are degraded, allowing the flax fibers to be separated from the plant core. Retting also helps to split the bundles into individual fibers [Hann,2005].

The traditional retting methods used for the commercial fiber extraction are dew and water retting. In dew retting, the flax plants are spread evenly on the field, and left there for several weeks [Hann,2005, Mohanty, et al.,2005], depending on the weather conditions. The fungi colonize the stems and degrade the pectins and other organic compounds around the outer rind of the stalk. A very dry climate prevents microorganisms from colonizing the stems, producing under-retted fibers, which are coarse and have many contaminating shives. In contrast, if the weather is very wet, retting progresses too far and the cellulose of the fibers is damaged, making the fibers weak and of little value since they can no longer be used for wet spinning [Hann,2005]. In water retting, the stems are enclosed in modern tank retting- including open, closed and cascade systems-where they are immersed in warm water (30–40 ^{0}C) for a few days or in cold water for one or two weeks. After retting, the stems are washed and dried in the fields forming cones. The retting wastewater produced is a sort of high concentrated organic polluting and odorous effluent.

Over the past twenty years, environmental regulations requirements have become more and more stringent by the governments, due to the risk on human health and the ecology by environmental pollutants. In Egypt, Tanta Company for Oil and Flax generates retting wastewater with high organic loads, discharged into an agricultural drain course called``Roh Mahal``. Therefore, this industrial activity is currently being forced to adopt wastewater treatment technologies to meet discharge norms. Consequently, a comprehensive Company-funded one year study was started at the National Research Center (NRC)-Egypt. This project has the aim of reducing the environmental impacts of flax yarn production by developing an ecologically sustainable waste water treatment plant in compliance with the Egyptian law which regulates the discharge of industrial wastewater to the agricultural drainage system.

The main objective of this article is to present the developed complex treatment plant proposed to the Company, based on comprehensive experimental different treatments, and to investigate its cost indices.

Situation Analysis

Flax plant is the main raw material for the company production processing where water retting is primarily undertaken to separate the grains from the stem. Afterwards, different operating facilities are performed to produce flax fibbers, flax oils, different wood qualities, urea formaldehyde and spinning rods.

Within the framework of the project, a field survey is carried out to recognize and quantify sources of polluted effluents. It reveals that the Company wastewaters are generated mainly from the following sources: 1) Flax water retting from open and closed chambers with a discharge rate ranging between 300m^3/day to 340m^3/day. 2) Flax oil production wastewater mixed with municipal wastewater yielding a discharge rate of about 5m^3/day. 3). Collected wastewaters from wood and urea

formaldehyde factories in addition to other utilities resulting in a total discharge rate ranging between 60 m^3/day to70 m^3/day.

The effluent discharge limits the Company has to comply with depend on local environmental legislation. It is obvious that in case of discharging to a municipal sewer, discharge limits are less stringent than when the effluent is to be disposed into a sensitive water body to avoid the receiving waters ecosystem. As a consequence, a tailored monitoring program was conducted twice a month for three months to study the water quality, to determine upper and lower values for pollution and to compare these limits with permissible ones for discharge into ``Roh Mahal`` drain course. All analytical results are summarized in Table (1) – performed according to Standards Methods For The Examination OF Water And Wastewater[1992]- illustrating the upper values of the most relevant environmental parameters compared to indicative discharge standards in Egypt. It is obvious that these values are in disagreement with the recommended values specified in the applicable law.

At first sight, the flax water retting spent from retting chambers is identified to be the major source of pollutants both qualitatively and quantitatively.

Table 1: Maximum Pollutants Values for all Company Effluents

Samples Location	Retting water (closed chambers)		Retting water (open chambers)		Oil Facility		Other Facilities except retting water		Law 48/1982 modified by Decree N^o 402/2009. mg/l
Items	Grab mg/l	Comp.* mg/l	Grab mg/l	Comp.* mg/l	Grab mg/l	Comp.* mg/l	Grab mg/l	Comp.* mg/l	
pH	4.9	4.7	----	6.1	----	7.6	7.3	7.23	
TC D	5104	6718	1150	1565	8860	246	3387	560	20
DC D	4015	5820	745	947	------	-----	----	-----	20
B D	630	3300	220	765	160	180	982	350	800
TSS	203	2800	29	100	756	39	604	1222	1
P_4	1.25	5	0.5	1.1	3.1	2.5	2.45	1.2	----
NH_3	26	28	10	61	ND	4.3	ND	39.2	----
N_2	12	33.6	15	213	15	40	ND	69	1
H_2S_2	2.0	14	5	4	ND	5.6	13	8	5
il	100	519	213	135	21	67	23	44	

*Composite sample over 24 hr. working time.

Process Selection

Treatment plant design is one of the most challenging aspects of environmental engineering when selecting the treatment-process flow diagrams capable of meeting the permit requirements.

The methodology undertaken in the present project includes the conductance of a comparative study to explore retting wastewater treatment between different commercially practiced treatment technologies in order to determine the most reliable scheme in compliance with performance requirements.

Testing was carried out on two versions. The first test was conducted using advanced chemical oxidation methods, namely Fenton's oxidation reagents and electro-chemical oxidation processes, and both methods were not successful as they removed only from11% to 18% of the organic load in terms of the chemical oxygen demand (COD). The second test was performed using laboratory biological treatment which gives promising indicators for higher COD reduction. Pilot plant experimentation was thereafter planned and executed for both biological treatment systems: anaerobic and aerobic (activated sludge) processes, yielding about 70%-80% and 84% removal of COD respectively. The detailed experimentation study is reported elsewhere [Report:"Environmental Assessment Study for Tanta Flax and Oil Company, Monitoring, Controlling and Treating of Industrial Wastewater and Air Pollution"2012, Hafez, et al.,2012].

The above results allow to precisely considering, for this special case, anaerobic pre-treatment combined with subsequent aerobic post-treatment to be the prevailing solution for complete degradation of contaminants. When used as a combination, advantages of both processes are integrated. Accordingly, wastewaters from flax retting process in the company have been treated using pilot-scale anaerobic and aerobic sequencing reactors. Table (2) depicts the end results obtained by the combined systems.

Table 2: Load removal percent using combined systems

Items	COD, mg/l	BOD, mg/l	TDS, mg/l	SS, mg/l	TS, mg/l
Initial	5104	630	2592	203	2795
Anaerobic Treatment	1192	110	208	138	346
Removal Percent	77%	83%	92%	32%	88%
Initial*	1192	200	1465	1185	2650
Aerobic Treatment	289	30	630	295	1180
Removal Percent	76%	85%	57%	75%	56%
Accumulative Removal Percent	93%	95%	76%	75%	58%

*It is worth noting that at the aerobic treatment start-up, a portion of the sludge is added into the reactor.

As expected, the final effluent quality is improved when combined process is adopted: the anaerobic followed by aerobic treatments was able to achieve about 77% and 76% COD removal respectively resulting in an accumulative removal percent equal to 93%.

Still, in order to meet extremely stringent quality standards, further simple polishing step should be applied to comply with local law when discharging into surface bodies (about 20 mg/l COD), and- based on practical authors' experience- the Nanofiltration membrane process is selected to be used in a complimentary tertiary treatment to meet local discharge norms.

Flax Retting Tests

One of the most important environmental problems related with flax industry is the high consumption of process water. The reduction of fresh process water in comparison with the traditional one required for flax retting process is an important economical advantage for minimizing production costs and waste streams in the treatment process. Therefore, as recycling or reusing of industrial wastewater is one of the challenges resolving part of the shortage and/or high consumption of water supply, this concept was adopted during this work. Hence, flax retting experiments were done in this study to investigate the effect of different treatments on the fiber quality. The experiments were performed using three different effluents of treated retting water diluted with fresh water at a ratio of 1:1, according to the different company process steps: completely submerged flax, retting time 10 days till the pH became 4.5. After drying, the treated flaxes were investigated at the company quality control department according to their norms, and their accredited technical report have shown that the treated retting water by anaerobic followed by aerobic processes and diluted with fresh water at a ratio of 1:1 produced favored fiber strength with fiber percent reaching 21.53% by weight of flax, as demonstrated in Table (3).

Table 3: Results of Flax Retting Trials

Treated retting water process	Treated retting water characteristics			Retted flax characteristics		
	COD mg/l	BOD mg/l	TDS mg/l	Fiber percent, $\%_{wt}$	Fiber strength	Fiber color
Anaerobic	915	499	1212	20.25	poor	usual
Aerobic	797	210	1404	20.83	medium	usual
Combined	295	846	645	21.53	strong	usual

In fact, the renovated water generated by the combined biological treatment process could be reused in flax retting process with a fresh water make-up at one to one ratio, with which water resource could be recycled well in production process of the company.

Process Design of the Integrated Wastewater Treatment Plant

The developed wastewater treatment process is depending upon the following major parameters:

a. ***Wastewater characteristics,*** which are relevant to those of closed retting chambers since they represent maximum load values as follows:
   - High oil and fat concentration (100mg/l).
   - High total COD concentration (5104 mg/l).
   - High dissolved COD concentration (4015 mg/l).
   - High BOD concentration (630 mg/l).
   - High SS concentration (203 mg/l).

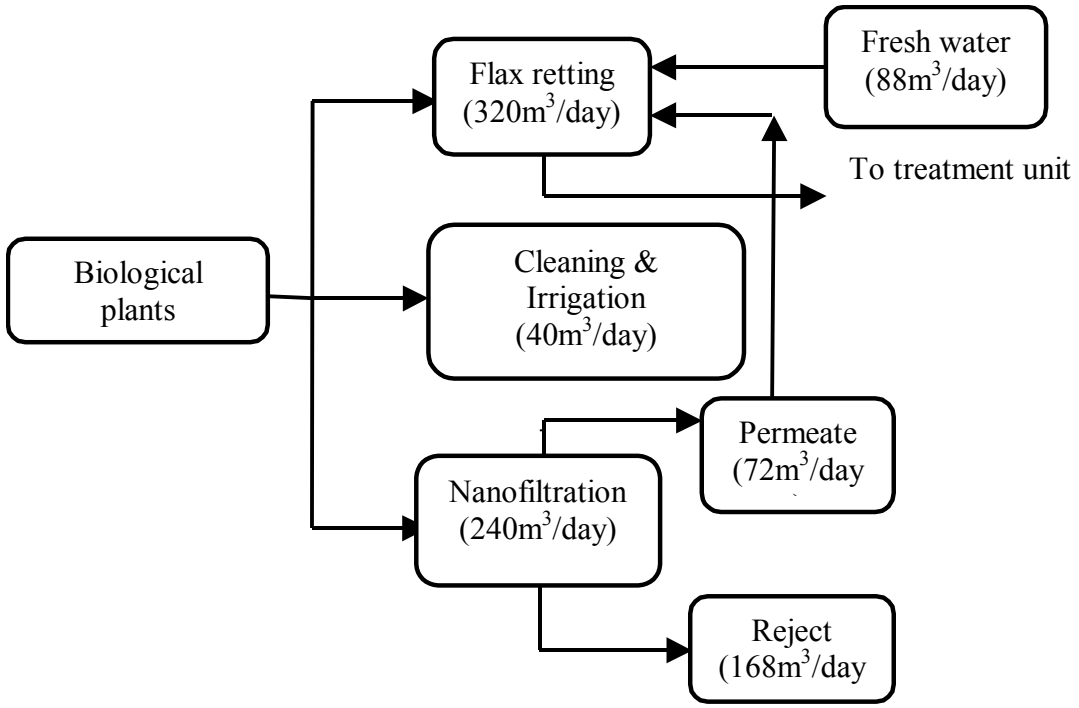
b. ***Experimental treatment results,*** which are already described above (process selection section).

c. ***Treatment plant capacity,*** which has been estimated from the company files to be 400m^3/day in the average as maximum water consumption for industrial and domestic uses. By considering a value of 10% as safety factor, the design capacity undertaken is 440m^3/day as maximum polluted water discharge.

Process Description

Wastewater treatment plants are usually classified as primary, secondary and/or tertiary treatment, depending on the purification level required and to which the plants provide. Thus, the proposed integrated treatment plant consists of a primary treatment by screening to remove large solid particles, an equalization tank in which wastewaters from all company facilities are collected to be pumped at 440m^3/day flow rate to a secondary treatment plant. This combined anaerobic/aerobic plant comprises an up-flow anaerobic sludge blanket (UASB) reactor reducing the loading to the aeration reactor (activated sludge) which enhances the removal efficiency of organic load to 94% in average. An external gravity clarifier for sludge separation subsequently follows the aerated basin where the produced sludge is partially returned to the aeration tank. The decanted biologically purified effluent, collected in a partially treated storage tank, is in exact conformity with its specified requirements for recycling, from which, 160m^3/day is diluted by 1:1 fresh water to be reused in the retting process in addition to another 40m^3/day is employed in ground cleaning and irrigation of the company green areas. The remaining 240m^3/day treated water exiting the aeration plant is flowed to the nanofiltration membrane unit for tertiary treatment, producing about 30% permeate water equivalent to 72m^3/day which is mixed with 88m^3/day fresh water to meet the amount of water dilution percent required for flax retting process. The 70% reject stream (168m^3/day) together with the produced and excess sludge from the biological plants are directed to solar drying lagoons, dewatered and put to landfill. Figure (1) demonstrates the flow diagram and uses of treated water, Figure (2) illustrates the equipment flowsheet for the treatment plant and Figure (3) shows the plant material balance based on ton/hr.

Figure 1: Effluents Treatment Plant Flow Diagram & Uses



As it can be seen, application of this proposed treatment plant realizes zero liquid effluents discharge in order to reduce the amount of fresh water employed.

Design Criterion

Design basis regarding influent wastewater flow and characteristics for the different treatment units were established based on pilot scale experimental results and literature, as shown in Table (4).

Table 4: Design Data for Biological Processes of Treatment Units

Process	Design Parameters
Anaerobic Treatment Unit	Hydraulic Retention Time: 16 hours. VSS: 0.162 Kg/m^3, SRT: 75 days. Organic Load on Sludge Blanket: 6.3 Kg COD/ KgVSS. Organic Load Rate: 1.68 Kg/day.m^3.
Aerobic Treatment Unit	Hydraulic Retention Time: 8 hours MLSS: 3500 mg/l, MLVS/ MLSS: 0.6. Kinetic Coefficients: Y=0.6 Kg/Kg & K_d = 0.06 day^{-1} [7]. Oxygen Demand of Biomass=1.42 mgO_2consumed/mgcell oxidized [8,9]. BOD_5 / BOD_L = 0.68 Effluent Biodegradable Portion= 50% .
Settling Unit	Residence Time = 4 hours. Initial Settling Velocity = 3 m/ hr. Sludge Volume Index (SVI) = 125mg/l [8].

With regards to the observed retention time changes, a design criterion for the three treatment plants is developed: a series of stages can be arranged so that the phases flow through the assembled stages from one to the other in a continuous fashion. Hence, the total wastewater plant capacity (440m^3/day) is divided into four anaerobic treatment units (16 hrs. mean residence time per tank) operating with a sequential descending time span equivalent to 4 hours. Each two stages are interconnected in series to an aerobic treatment unit (8hrs. mean residence time per tank) with the exit

streams of the first and the third anaerobic units serving as the feed to the first aerobic unit, while those of the second and fourth anaerobic units are serving as the feed to the second aerobic unit. Consecutive feeding to the settling unit (4hrs. mean residence time) from the aerobic units is undergoing from which the clarified partially treated water is pumped to a storage tank to be continuously redistributed according to the required flow sheet. Such assemblage is illustrated in the following Gant Chart (Figure 4). Based on the preliminary design, the resultant values of major calculated parameters in the daily operation of the wastewater treatment facilities are depicted in Table (5).

Figure 2: Equipment Flow Diagram of Wastewater Treatment Plant

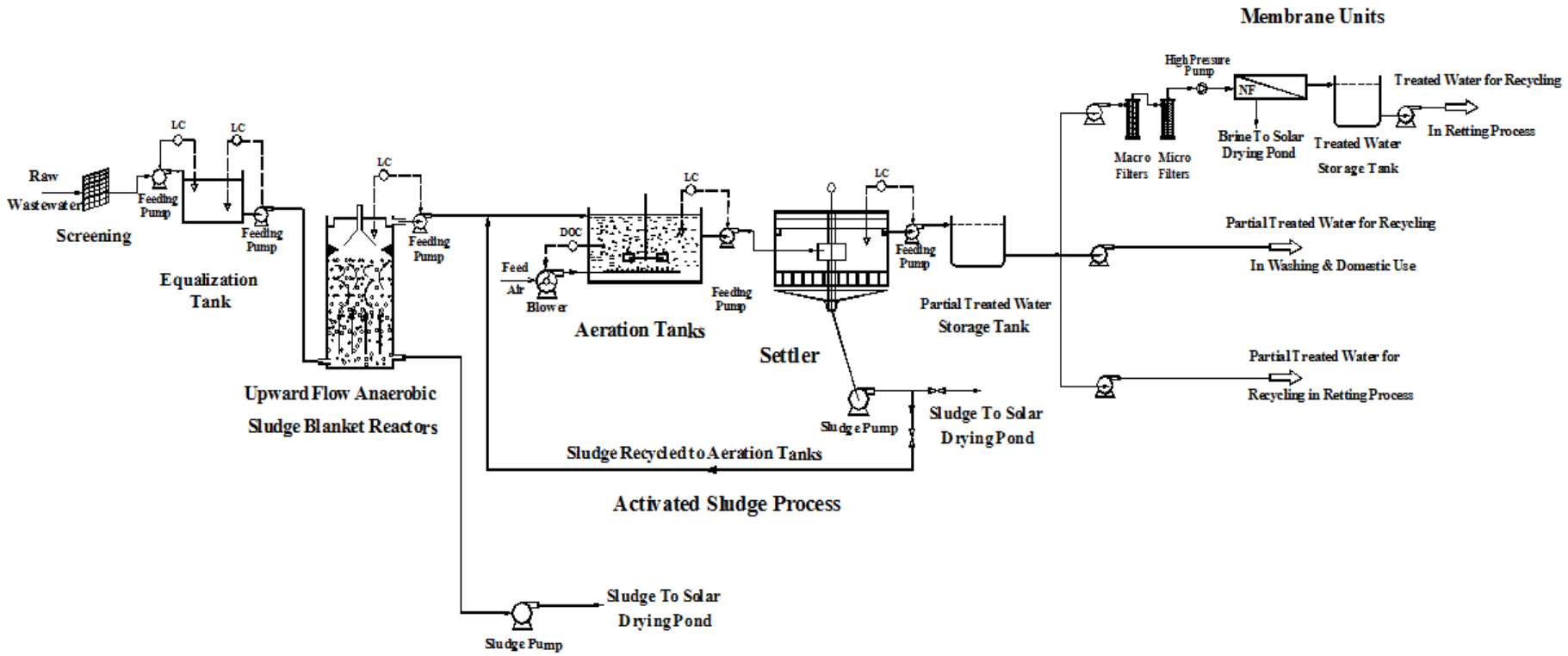


Figure 3: Material Balance of Treatment Units

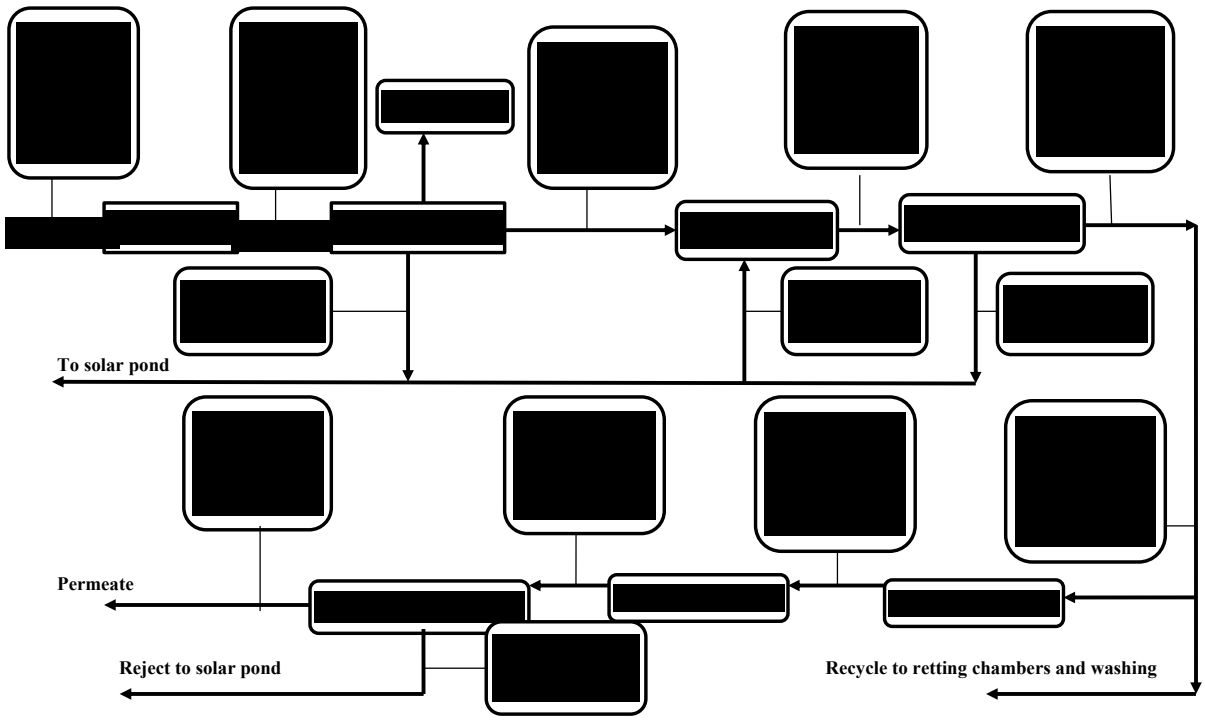


Figure 4: Gant Chart of Biological Treatment Plants

Treatment Unit	Time Interval,(hr.)						
	0 - 4	4 - 8	8 -12	12-16	16-20	20-24	24-28
-UASB (1) -Aerator(1) -UASB(2) -Settler -Aerator(2) -UASB (3) -UASB (4)							

Table 5: Resultant Values of Treatment Process Design

Process	Design Parameters And Specification
Anaerobic Treatment (UASB unit)	• Working reactor= 4, designed volume/reactor= 146m^3 (D=4.8m,H_t=8.1m) • Organic load rate= 1.68 kg/m^3.day • Sludge Production= 0.346 kg/m^3, sludge retention time= 60 days. • Gas production= 546m^3/day.
Aerobic Treatment (Complete-mix Activated Sludge)	• Working reactor=2, designed volume/reactor=59m^3 (D=5m, H=3m). • Aeration type: Sparger Turbine (Impeller tip speed 3m/sec.) • Mean cell residence time=11.67days, F/M*=0.286day^{-1}, U*=0.243day^{-1}. • Oxygen required=18kgO_2/day, Oxygenation capacity= 0.21kgO_2/kw.hr.
Settler	-Wasted sludge= 4.4kg/day, conc.=8000ppm, recycle ratio= 36%.
Nanofiltration Unit	• Macro-filtration: 5 Cartridge filters (1-5micron each), rate=2m^3/hr. • Micro-filtration: 5 Cartridge filters (0.1-0.2 micron each), rate=2m^3/hr. • High pressure pump: 10 bar. • Membrane Spec.: 42 Composite modules (L=40in.&D=4in./each), 7 vessels, 6modules/vessel, flow rate=6.7m^3/day, rejection percent=99.6%.

Economic Evaluation of Integrated Wastewater Treatment Plant

Cost Estimation

Cost estimation for the selected wastewater treatment plant is a requirement for quick evaluation of designed schemes. Wastewater treatment costs are basically divided into two categories: total capital investment (TCI) costs, incurred during plant construction, and annual operating and maintenance (O&M) costs, necessary to provide sustained operation for the plant components following construction. Data on capital costs, O&M costs were collected from various reliable sources. As the cost of the purchased-equipment is the basis for estimating capital investment, the delivered nanofiltration equipment cost- obtained from a firm supplier offer- is equivalent to 466420 Egyptian Pounds (LE) for 240 m^3/day capacity. While the biological processes units construction cost and equipment cost is obtained from a convenient similar processes data [Zahid,2007], where the cost figure is 144077000 Saudi Riyals based on year 2006 prices [1SR=1.06 LE (year 2006)]. For pricing the present designed unit , this cost value is corrected to the desired capacity by application of the six-tenths-factor rule, followed by adjustment to the present cost using Marshall & Swift Cost Index taken 2006 as the base year [Ulrich and Vasudevan,2004].Unit prices for utilities (e.g. labor salaries, chemicals, laboratories supplies and analyses) are acquired from local market. Other cost input parameters are as follows:

- The economic life of biological (anaerobic and aerobic) plants and nanofiltration plant to be in a reliable operation has been considered as 30 years and 10 years respectively.
- The amortization cost is estimated by multiplying the fixed capital cost by the capital recovery factor (CRF) at an interest rate of 8% over the life period (CRF = 0.089 & 0.149 for biological and nanofiltration units respectively) [McGhee,1991].
- Operating labor rate is taken as 10 LE/ hr working over 330 days per year.
- The electricity consumption rate is taken as 0.30 LE/Kw-hr, [the plant consumes 2.8hp for feeding pumps and 4.2hp for the high-pressure pump (10 bars at 240m^3/day) of the nanofiltration plant].

Tables (6 & 7) summarize the results of cost estimating for the treatment plant. As can be seen, the total project cost of the developed wastewater treatment plant is evaluated at about 5.6 million LE, and, in terms of the treated water, the values for the biological plant (partially treated water for recycling) and the nanofiltration plant (finally polishing treated water) are estimated at 3.35 LE/m^3 and 2.35 LE/m^3 respectively.

Profitability Estimation

Generally, profit is defined as the difference between income and expenses and as such, is a function of the quantity of goods produced and the selling price. But in the present case, as there is no product to be sold, the yearly profit is expressed in terms of the annual saving and/or revenue gained by the Company by implementing this project. The considered saving are the cost of recycled water, the cost of energy generated in terms of the biogas produced and the environmental violation cost charged by the government. Cost input parameters are as follows:

- Recycled water cost is estimated at 1.65 LE/m^3.
- Environmental Charges are determined at 5 LE/m^3wastewater.
- Cost of energy generated is estimated at 3$ per million of thermal units [1$= 6.67 LE].
- Calorific value of a typical biogas sample (80% CH_4) is around 8660 Kcal/m^3 [Trehan,2002].

The calculated revenue and the annual percent return on investment are illustrated in Table (8).

Table 6: Cost Estimation of Total Capital Investment for the Wastewater Treatment Plant

Components	Cost of Biological Systems, (LE).	Cost of Nanofiltration Unit,(LE).
a-Direct Costs		
• Purchased delivered-equipment, (E)	2290820	466420
• Equipment installation, (20%E)	458164	93284
• Instrumentation & controls,(10%E).	229082	46642
• Piping,(20%E).	458164	93284
• Electrical,(5%E).	114541	23321
• Buildings,(not required).	-------	-------
• Yard Improvement, (not required).	-------	-------
• Service facilities,(1%E).	22908	4664
• Land (not required).	--------	-------
Total Costs (D)	**3573679**	**727615**
Total Direct Cost, (TDC).	**4301294**	
b-Indirect Costs		
• Engineering & supervision,(2%FCI).	78465	15976
• Construction expenses,(1%D).	35737	7276
Total Indirect Cost,(I).	**114202**	**23252**
Total Costs (D+I).	**3687881**	**750867**
Total Direct & Indirect Costs.	**4438748**	
c-*Contractor's fee* .(1%FCI)	39233	7988
d-*Contingency,* (5%FCI).	196164	39940
Fixed Capital Investment, (FCI).	**3923278**	**798794**
Total Fixed Capital Investment, (TFCI).	**4722072**	
Working Capital,(~15% TCI).	**833307**	
Total Capital Investment,(TCI).	**5555379**	

Table 7: Cost Estimates of Annual Treated Wastewater

Components	Cost of Biological Systems, (LE).	Cost of Nanofiltration Unit,(LE).
a-Direct Production Costs		
• Chemicals	2000	8000
• Electricity	4990	7484
• Maintenance& Repair, (2%E).	45816	9328
• Laboratories Analysis	12000	12000
• Labors Salaries	52800	26400
b-Fixed Charges		
• Insurance (0.5% FCI).	19616	3994
• Amortization.	349172	119020
Total Annual Cost (TAC).	**486394**	**186226**
Treatment Cost, (LE/m^3)	**3.35**	**2.35**

Table 8: Rate of Return on Investment.

Components	Biological Systems Saving (LE)	Nanofiltration Unit Saving (LE)
Recycled Water Cost	108900	39204
Generated Energy Cost	124460	Nil
Environmental Charges	726000	396000
Total Saving	959360	435204
Revenue*	472966	248978
Rate of Return on Investment	**10.25 %**	**26.5%**

*The revenue is defined as the difference between the total saving and the annual operating cost.

Conclusion

In most of the developing countries, like Egypt, industrial wastewater treatment technologies that can provide effluent standards at minimum cost are generally preferred. As such, a developed integrated system to treat flax retting wastewater, generated at Tanta Company for Oil and Flax is established. A previous comprehensive experimental study is used as a tool for selecting appropriate technology for this special case. It supports that combined anaerobic-aerobic treatment using a UASB reactor in conjunction with an activated sludge process, in combination with adequate post-treatment reliable option, namely a nanofiltration unit, offers the best proposition for treatment from all aspects. In fact, the developed sequential biotechnological-nanofiltration technology is not only favorable to improve the Company effluent quality for environmental protection, but also to achieve Zero discharge by recycling and reusing the treated water in the Company processes. Based on system components process design, preliminary cost evaluation for 440m^3/day biological treatment plant and 240m^3/day nanofiltration treatment unit is investigated, resulting in10.25 % and 26.5% rate of return on investment respectively.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.339-353
http://www.europeanjournalofscientificresearch.com

The Application of Averaging Model for the Optimized Cascade PI Controllers of Buck Converters using Artificial Intelligence Techniques

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Abstract

This paper presents the application of the averaging model of the buck converters derived from the generalized state-space averaging method to the optimal controller design of the buck converters. The proposed dynamic model is used with the artificial intelligence techniques to design the cascade PI controllers of the buck converter so as to achieve the best output performance. The averaging model of the buck converters is used as an objective function instead of the exact topology model from software packages to reduce the simulation time. Moreover, the stability criteria based on the eigenvalue theorem can be included into the searching process via the proposed mathematical model to confirm the stable operation. The results from the simulation and the experiment show that the proposed method can provide the best output performance compared with those designed from the conventional method. Moreover, this approach is convenient and flexible for electrical engineering to design the controller of power electronic systems with good performances.

Keywords: Cascade PI controllers, Generalized state-space averaging method, Adaptive tabu search, Particle swarm optimization, Buck converter, Modeling, Simulation, Artificial Intelligence

1. Introduction

Presently, power electronic converters are widely used in many applications. For the system analysis and design, the dynamic model of the power electronic based system is very important. Unfortunately,

the power converter model is time-varying in nature because of the switching behaviour in which it is very complicated for a system analysis and design. Hence, several approaches are commonly used for eliminating the switching actions to achieve a time-invariant model. Then the classical linear control theory can be easily applied for the system analysis and design. For DC/DC converters, the generalized state-space averaging (GSSA) method is normally used to achieve the averaging model (time-invariant model) (Emadi, 2004; Gatto et al., 2011; Bor-Ren et al., 2010; Isastia and Meo, 2011). This method has been also used to analyze uncontrolled and controlled rectifiers in single-phase AC distribution systems (Emadi, 2004). and 6 and 12- pulse diode rectifiers in three phase systems (Han et al., 2007).

The artificial intelligence (AI) techniques are widely applied to many works of engineering such as the system identifications using adaptive tabu search (ATS) (Puangdownreong et al., 2002; Sujitjorn et al., 2006; Puangdownreong et al., 2005; Kulworawanichpong et al., 2005; Kulworawanichpong et al., 2004). the protection design in power system via ATS (Areerak et al., 2004). the active power filter design using genetic algorithm (GA) (Narongrit et al., 2010). power loss minimization using particle swarm optimization (PSO) and artificial bee colony (ABC) (Leeton et al., 2010). reactive power optimization for distribution systems based on ant colony optimization (ACO) (Lirui et al., 2008). and etc.

According to the literature review papers, the aim of this paper is to extend the work of (Chonsatidjamroen, et al., 2012) in which it presents the idea how to design the controller of buck converter to achieve the best output response by using the artificial intelligence techniques called the ATS and PSO algorithms. This is because the ATS algorithm has the mathematical proof to confirm that the algorithm can escape the local solution. As for the PSO algorithm, it is very simple compared with other AI-based heuristic optimization techniques. The structure of the controller in the paper is the PI cascade having the current loop control as the inner loop and voltage loop control as the outer loop (Tsang and Chan, 2005). Normally, the simple block diagram is used for the controller design using the conventional method in which some system dynamic is ignored. Hence, in the paper, the averaging model derived from the GSSA method is applied to analyze the buck converter to achieve the dynamic model that can explain the behaviour of the whole system. In addition, when the controllers are designed via the ATS or PSO methods, the searching process needs to simulate the power electronic system for each tuned controller parameter until the appropriate parameters are obtained. It is well know that the transient simulations of the power electronic system consume the vast simulation time due to the switching devices in the circuit. Therefore, according to the huge simulation time of the switching devices, the application of AI techniques is not widely applied to design the controller of the power converter. To solve the simulation time problem, the proposed averaging model derived from the GSSA method can be also used in the paper instead of the exact topology model. Before using the reported mathematical model, this model has to be compared with the intensive time-domain simulation via the full switching model of software package in terms of accuracy and simulation time. The comparison results will show later that the proposed mathematical models provide high accuracies in both transient and steady-state responses with the faster simulation time. Hence, the reported model derived from the GSSA method is suitable for the optimal controller design via the ATS and PSO algorithms. In this paper the additional results from the work of (Chonsatidjamroen, et al., 2012) are that the stability analysis based on the eigenvalue theorem (Areerak et al, 2011; Areerak et al, 2012) is included to confirm the stable operation during the searching process via the averaging model with AI algorithms. Moreover, the final results from the simulation and the experiment show that the proposed technique using the ATS and PSO algorithms with the averaging model can be used to design the controller of buck converter in which the better output response is obtained compared with the waveforms from the conventional design method.

The paper is structured as follows. In Section 2, considered system with deriving the dynamic model by using the GSSA modelling methods is firstly explained. Moreover, the comparison results between the reported model and the full switching model from the commercial software package in

terms of accuracy and simulation time are also illustrated in Section 2 to ensure that the proposed model can explain the dynamic of the whole system with the fast simulation time. In Section 3, the controller designs using the ATS, PSO, and the conventional method are addressed. The simulation results are fully shown in Section 4. In addition, the experimental results are also given in Section 5 to support the simulation results. Finally, Section 6 concludes and discusses the advantages of the proposed technique for the optimal controller design of the power electronic systems.

2. Dynamic Model of Studied System

The power system considered in this paper is shown in Fig.1. It consists of a DC voltage source V_{in}, the elements of buck converter represented by L and C, the resistive load R, and the PI controllers of current loop (inner loop) and voltage loop (outer loop) represented by K_{pv}, K_{iv}, K_{pi}, and K_{ii}, respectively. The schematic of cascade PI controllers for a buck converter is depicted in Fig.2.

Figure 1: The regulated buck converter with a resistive load

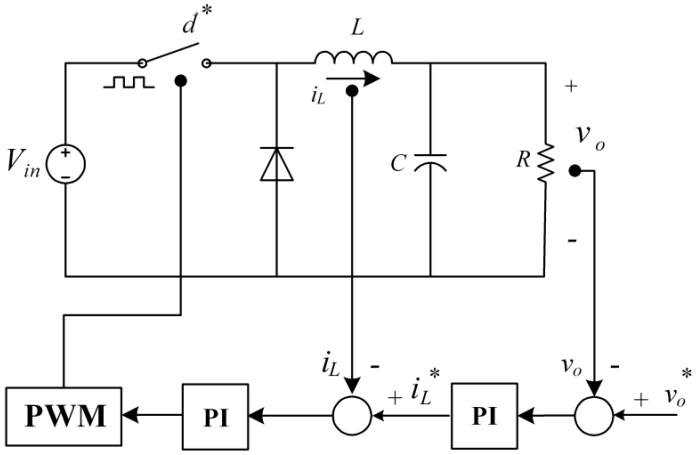
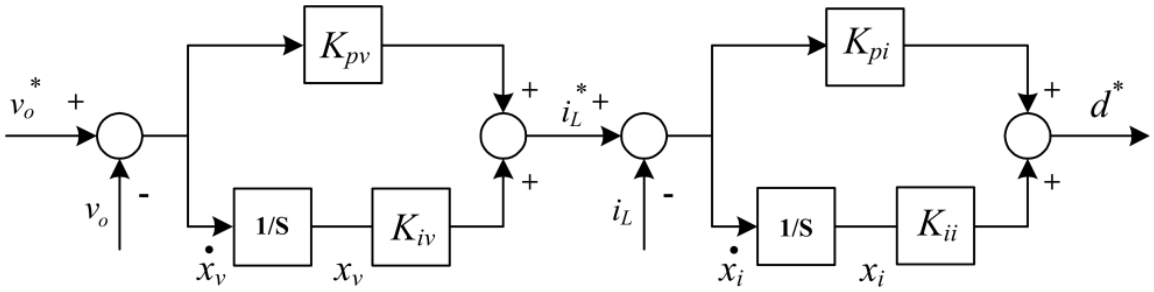


Figure 2: The schematic of buck converter controllers



The dynamic model of a controlled buck converter as shown in Fig.1 derived from the GSSA modeling method can be written as:

$$\begin{aligned} \dot{\mathbf{x}} &= \mathbf{A}\mathbf{x} + \mathbf{B}\mathbf{u} \\ \mathbf{y} &= \mathbf{C}\mathbf{x} + \mathbf{D}\mathbf{x} \end{aligned} \tag{1}$$

where state-variable: $\mathbf{x} = \begin{bmatrix} i_L & v_o & x_v & x_i \end{bmatrix}^T$, input: $\mathbf{u} = \begin{bmatrix} v_o^* \end{bmatrix}$, and output: $\mathbf{y} = \begin{bmatrix} v_o \end{bmatrix}$

The details of **A**, **B**, **C**, and **D** are as follows:

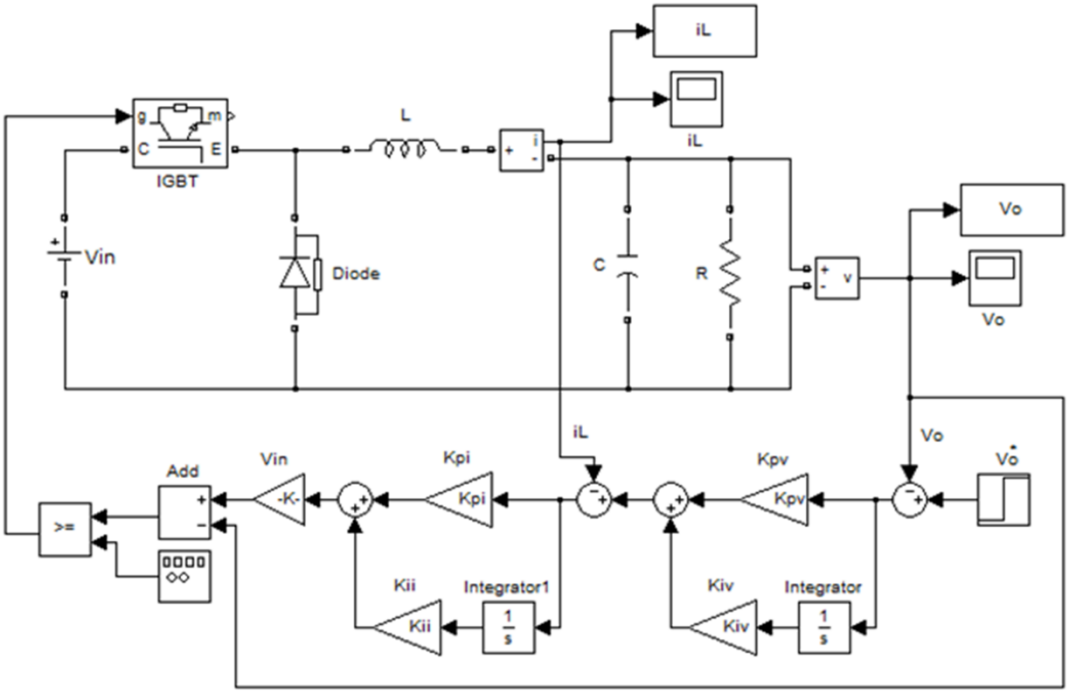
$$\mathbf{A}=\begin{bmatrix} -\frac{K_{pi}V_{in}}{L} & -\frac{K_{pv}K_{pi}V_{in}+1}{L} & \frac{K_{iv}K_{pi}V_{in}}{L} & \frac{K_{ii}V_{in}}{L} \\ \frac{1}{C} & -\frac{1}{RC} & 0 & 0 \\ 0 & -1 & 0 & 0 \\ -1 & -K_{pv} & K_{iv} & 0 \end{bmatrix}_{4\times4}$$

$$\mathbf{B}=\begin{bmatrix} \frac{K_{pv}K_{pi}V_{in}}{L} \\ 0 \\ 1 \\ K_{pv} \end{bmatrix}_{4\times1}, \mathbf{C}=\begin{bmatrix}0 & 1 & 0 & 0\end{bmatrix}_{1\times4}, \text{ and}$$

$$\mathbf{D}=\begin{bmatrix}0\end{bmatrix}_{1\times1} \quad (2)$$

Notice that the cascade PI controller parameters (K_{pv}, K_{iv}, K_{pi}, and K_{ii}) appear in the dynamic model as given in (2). Before using the averaging model of (1) with the details of **A**, **B**, **C**, and **D** as given in (2), the transient simulation from the reported model has to be compared with those from the commercial software package; here is the SimPowerSystem™ (SPS™) of SIMULINK. The exact topology model of SPS™ for the system in Fig.1 is depicted in Fig. 3. The more details how to derive the model of the buck converter with the cascade PI controllers using the GSSA method can be found in (Chonsatidjamroen et al., 2011).

Figure 3: The full topology model in SPS™ of SIMULINK



The set of parameters for the system in Fig.1 is given as follows: R = 20 Ω, L = 15 mH (ΔI = 0.12 A), C = 150 μF (ΔV = 10 mV), V_{in} = 100 V, and T_s = 0.1 ms. Fig. 4 and Fig. 5 shows the comparisons of the output voltage responses and the inductor current of the system in Fig. 1 between the exact topology model as given in Fig. 3 and the averaging model as given in (1) to a step change of

the voltage command v_o^* from 40 V to 50 V that occurs at t = 1 s., respectively. Similarly, Fig. 6 and Fig. 7 show the comparison responses for a step change of the voltage command v_o^* from 40 V to 70 V that occurs at t = 1 s.. The parameters of PI controllers for Fig. 4-Fig. 7 are designed via the conventional method by setting the bandwidth of current loop is faster than the bandwidth of voltage loop by 10 times. The PI controller parameters for this case are K_{pv} = 0.01, K_{iv} = 9.375, K_{pi} = 0.6, and K_{ii} = 937.5 in which ω_{nv}, ζ_v, ω_{ni}, and ζ_i are equal to 250 rad/s, 0.8, 2500 rad/s, and 0.8, respectively. The details how to design the PI controllers using the classical method for buck converter having the schematic as depicted in Fig. 2 can be found in (Tsang and Chan, 2005).

Figure 4: Response of vo for changing the v_o^* from 40 V to 50 V

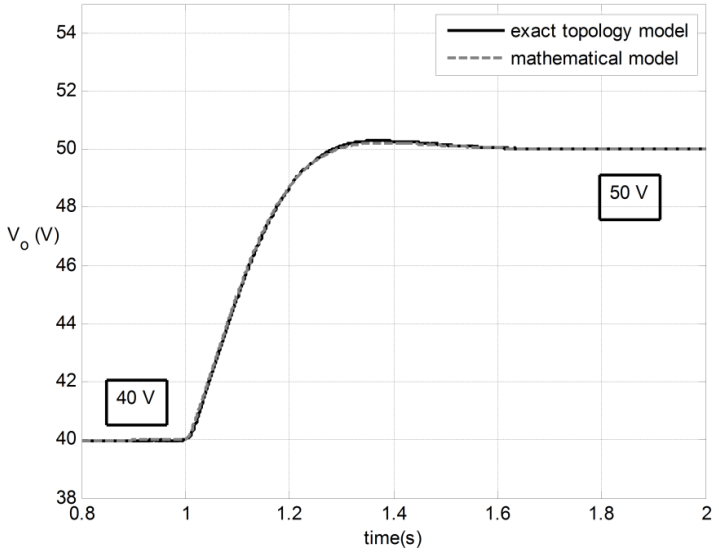


Figure 5: Response of i_L for changing the v_o^* from 40 V to 50 V

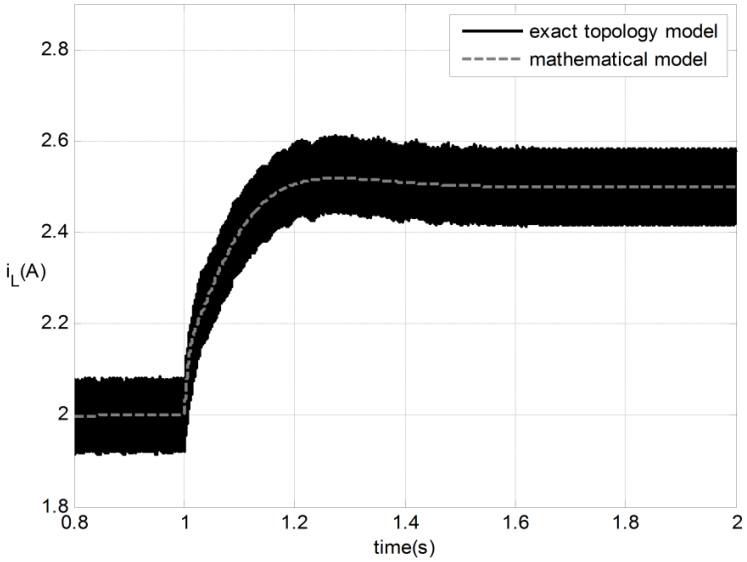


Figure 6: Response of v_o for changing the v_o^* from 40 V to 70 V

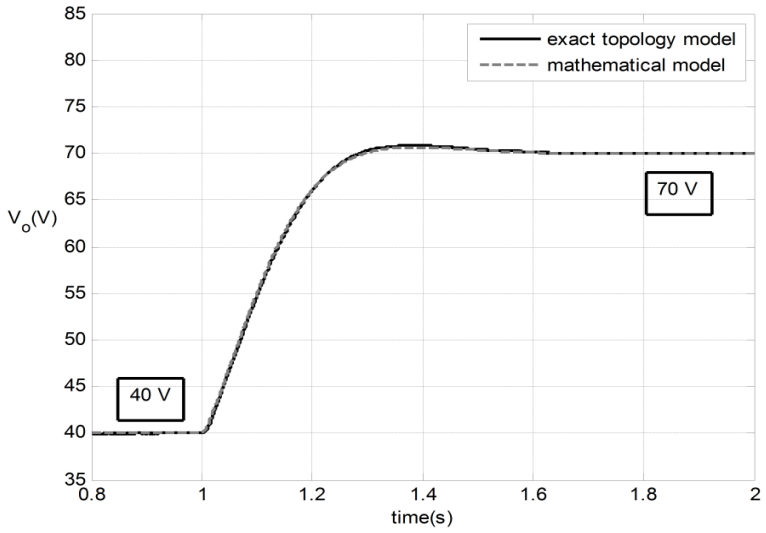
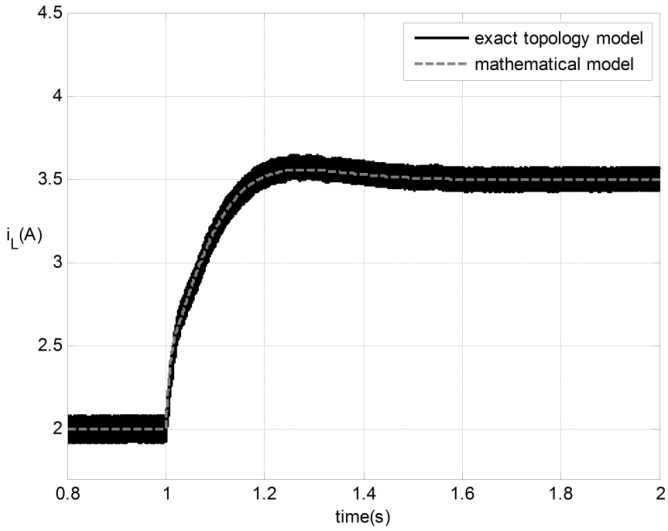


Figure 7: Response of i_L for changing the v_o^* from 40 V to 70 V



From the comparison results of both models as shown in Fig. 4- Fig. 7, it confirms that the mathematical model of the power system with a controlled buck converter derived from the GSSA method provide a good accuracy in both transient and steady-state responses. The model can describe the dynamic behaviour of the whole system. Moreover, the simulation time when the system was simulated via the proposed model coding in MATLAB requires 8.82 second, while the full topology model of SPS^{TM} consumes 1920 second. Hence, the proposed model as described in this section is suitable for the optimal controller design of the buck converter via the PSO algorithm because the very fast simulation time can be achieved. Moreover, the eigenvalue of the system can be calculated from matrix **A** in (2) during the searching process in which the PI controlled parameters are varied following from the ATS or PSO algorithms. For this case, the stability analysis based on the eigenvalue theorem can be applied during the searching process via the proposed GSSA model.

3. Controller Designs

In this section, the controller designs for the buck converter via the conventional, ATS, and PSO methods are illustrated.

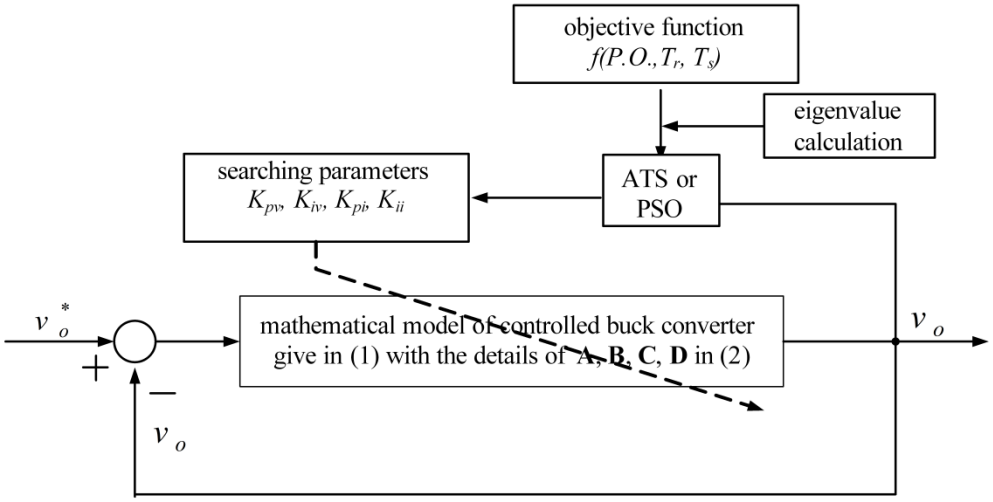
3.1. Conventional Method

The details of PI controller design using the conventional method via the simple block diagram can be found in (Tsang and Chan, 2005). The PI parameters for the conventional method in this paper are designed by selecting $\zeta_v = 0.8$, $\zeta_i = 0.8$, $\omega_{ni} = 2500$ rad/s, and $\omega_{nv} = 250$ rad/s. Hence, the PI controller parameters designed by the conventional method are given by $K_{pv} = 0.01$, $K_{iv} = 9.375$, $K_{pi} = 0.6$, and $K_{ii} = 937.5$.

3.2. ATS Algorithm

The block diagram to explain how to search the PI controller parameters using ATS algorithm is shown in Fig.8. The mathematical model derived from the GSSA method is used to simulate the system during the search process in which the computational time can considerably reduced.

Figure 8: The AI methods for the cascade PI controller design



In Fig.8, the ATS algorithm will search the appropriate controller parameters K_{pv}, K_{iv}, K_{pi}, K_{ii} in which the objective value (W) is defined by

$$W(T_r, T_s, P.O.) = \sigma T_r + \alpha T_s + \gamma P.O. \tag{3}$$

and

$$\sigma + \alpha + \gamma = 1 \tag{4}$$

where

$P.O.$ is the percent overshoot of the v_o response.

T_r is the rise time of the v_o response.

T_s is the setting time of the v_o response.

σ, α, and γ are the priority coefficients of T_r, T_s, and $P.O.$, respectively.

In this paper, the values of σ, α, and γ are set to 0.34, 0.33, and 0.33, respectively. The ATS searching method will try to search the best controller parameters until the minimum W is achieved. It means that the controller parameters from the searching process provide the best performance of the v_o response. In addition, during the searching process, the eigenvalue is calculated via the matrix **A** in (2) to confirm that the controllers from the ATS can provide the best performance with the stable operation.

According to Fig.8, the steps of searching controller parameters by using ATS are as follow:

Step 1: Determine the boundary of parameters. In this paper, the upper and lower limits of K_{pv}, K_{iv}, K_{pi}, K_{ii} are set to [0.0027 0.1347], [3.3750 73.50], [1.6 16], [2000 200000], respectively. These boundary values are calculated by using ω_{ni} = 2π×2000 to 2π×20000 rad/s and ω_{nv} = 2π×150 to 2π×700 rad/s with the constant ζ=0.8 and the system parameters as defined in Section 2.

Step 2: Define the initial value for each parameter by random within the search space.

Step 3: Define the radius value (R), the one of ATS parameters.

Step 4: Define the condition for ATS back tracking.

Step 5: Define the cost value, here is W calculated from the objective function as given in (3).

Step 6: Define the maximum of searching iteration for ATS ($count_{max}$). This value is set as a stop criterion for ATS algorithm. In this paper, it is equal to 300 iterations. Note that the more details of ATS algorithm can be found in (Sujitjorn et al., 2006).

3.3. PSO Algorithm

According to Fig.8, the steps of searching controller parameters by using PSO are as follow.

Step 1: Determine the boundary of parameters (the same as ATS algorithm).

Step 2: Define the initial value for position and velocity vectors by random within the search space as defined from Step 1.

Step 3: Define the NP = 60, C_p = 2, and C_g = 1.75.

Step 4: Define the fitness value, here is W given by (3) in which it can be calculated from the output response of the objective function as given in the model of (1).

Step 5: Define the maximum of searching iteration for PSO ($NT_{\max}$). In this paper, it is equal to 300 iterations.

The more details of PSO algorithm can be found in (Leeton et al., 2010).

4. Simulation Results

In this section, the system as shown in Fig.1 having the controllers designed by using the ATS, PSO, and the conventional methods is simulated by using SPS™ in SIMULINK as given in Fig. 3. The aim of the ATS and PSO approaches are to minimize the W value to achieve the best output voltage response. The comparison results of the controller parameters that are designed from the difference methods are given in Table 1.

Table 1: The Comparison between ATS and Classical Methods

Controller Parameters	Design Methods		
	Conventional Method	PSO Method	ATS Method
K_{pv}	0.0027	0.1228	0.1174
K_{iv}	3.3750	27.1625	25.9984
K_{pi}	2.4	9.3736	11.4548
K_{ii}	4500	70103	77629
W	0.6821	0.0034	0.0030

According to Table 1, the controllers designed from the ATS and PSO methods provide the minimum W value compared with those of the classical method. Fig.9 shows the v_o response to a step change of v_o^* from 15 V to 20 V that occurs at t = 0.15 second. The comparison results show that the

output response when the controllers designed by the ATS and PSO methods is better than that from the conventional method in terms of percent overshoot, rise time and setting time under the changing of command input. In addition, the convergences of *W* value during the ATS and PSO searching processes are depicted in Fig.10 and Fig. 11, respectively.

Figure 9: The comparison results of v_o response

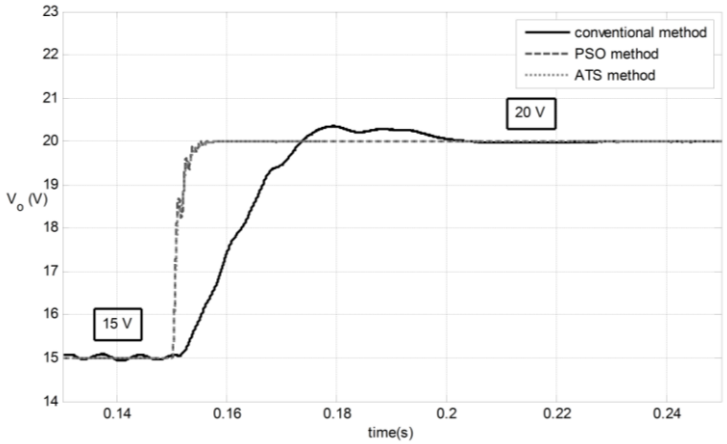


Figure 10: The convergence of *W* value from the ATS method

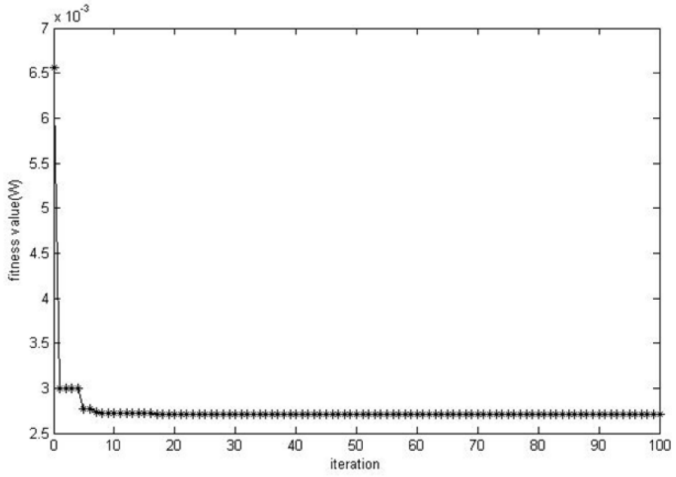
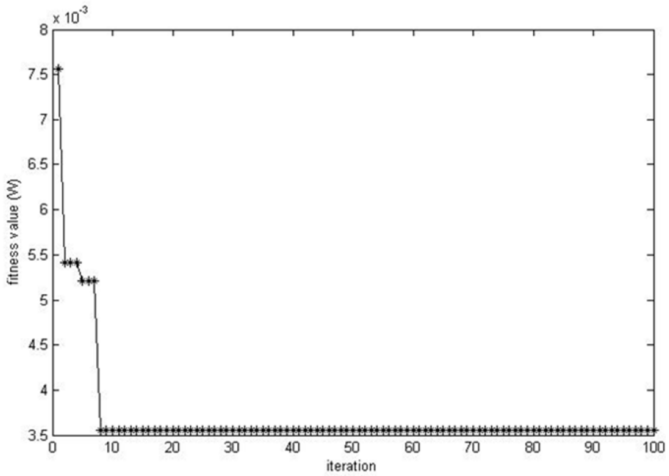


Figure 11: The convergence of W value from the PSO method



As for the stability analysis, the eigenvalues of the system during the searching process from the ATS and PSO algorithms are depicted in Fig. 12 and Fig. 13, respectively. There are four eigenvalues for the proposed system having the dynamic model as given in (1) and (2). It can be seen that these eigenvalues of the best solution from the proposed searching methods are located on the left-hand side of the s-plane. Based on the eigenvalue theorem, it means that the system with the controller parameters designed from the ATS and PSO algorithms can provide the stable operation.

Figure 12: The eigenvalue plot during the ATS searching process

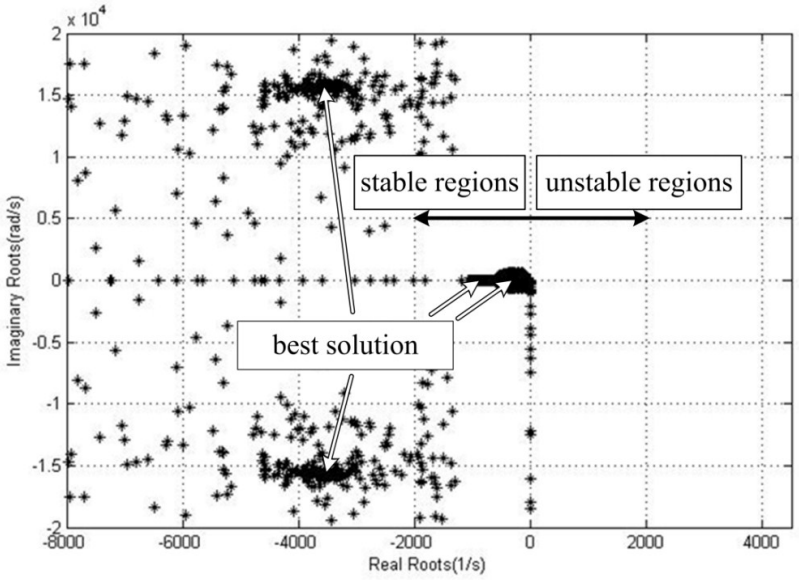
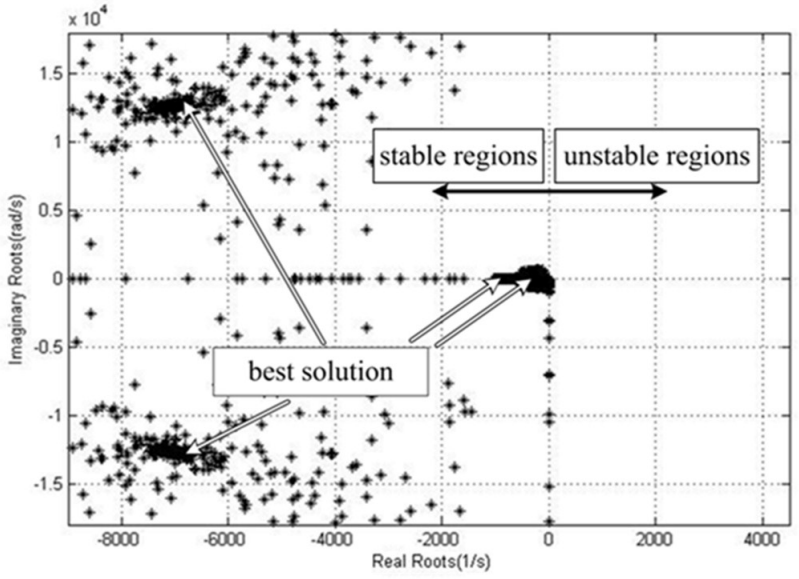


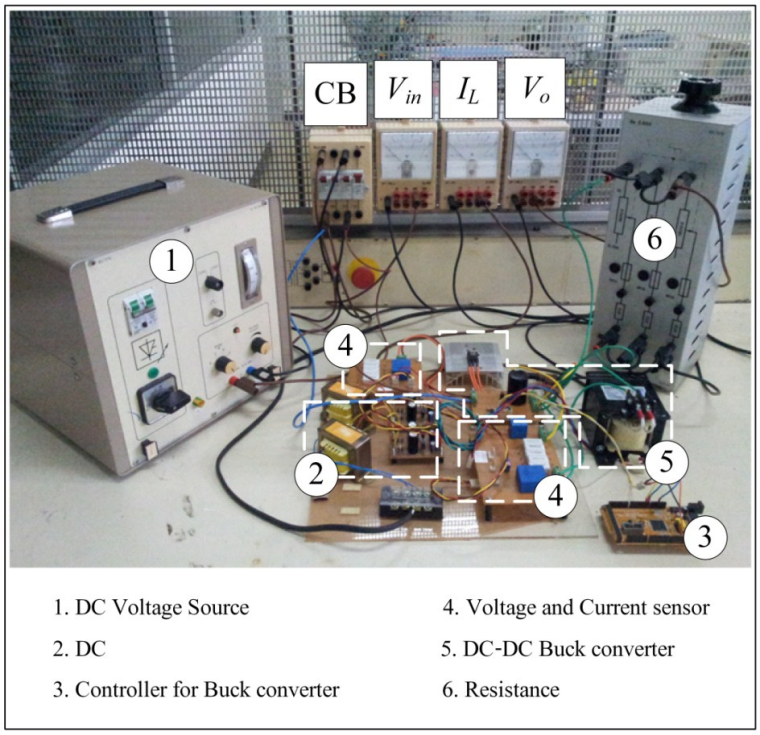
Figure 13: The eigenvalue plot during the PSO searching process



5. Experimental Results

The test rig of the system in Fig. 1 is shown in Fig. 14.

Figure 14: The testing rig of the system in Fig. 1



The controller of the rig was implemented using. The buck converters have been constructed using 3A and 220 V.

The PI controller parameters as shown in Table 1 were coded in the microcontroller of the rig in Fig. 14. The comparison of the output voltage response between the controllers designed from the conventional and the ATS methods for a step change of the voltage command v_o^* from 10 V to 12 V that occurs at t = 0.1 s is given in Fig. 15. Fig. 16 is the results when the controllers are designed from the PSO algorithm. Similarly, for other operating points, the experimental results using the PI controller parameters designed from the ATS and PSO methods for a step change of the voltage command v_o^* from 10 V to 14 V and 10 V to 16 V are shown in Fig. 17-Fig. 20, respectively.

Figure 15: The experimental results of v_o for changing the v_o^* from 10 V to 12 V

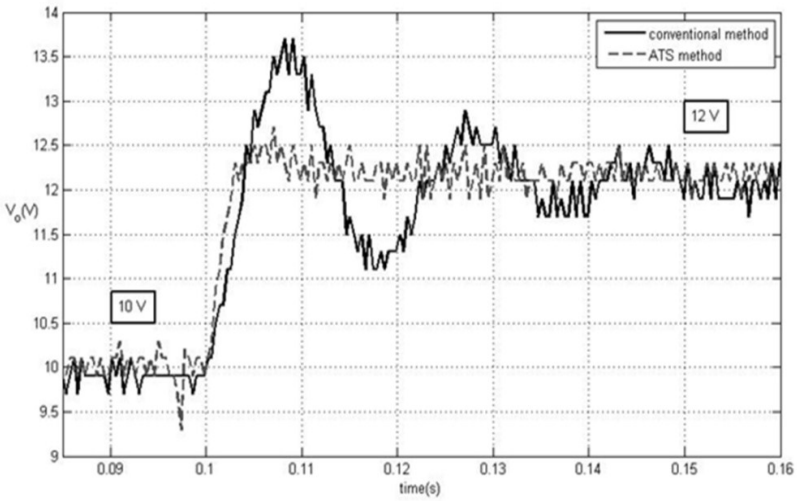


Figure 16: The experimental results of v_o for changing the v_o^* from 10 V to 12 V

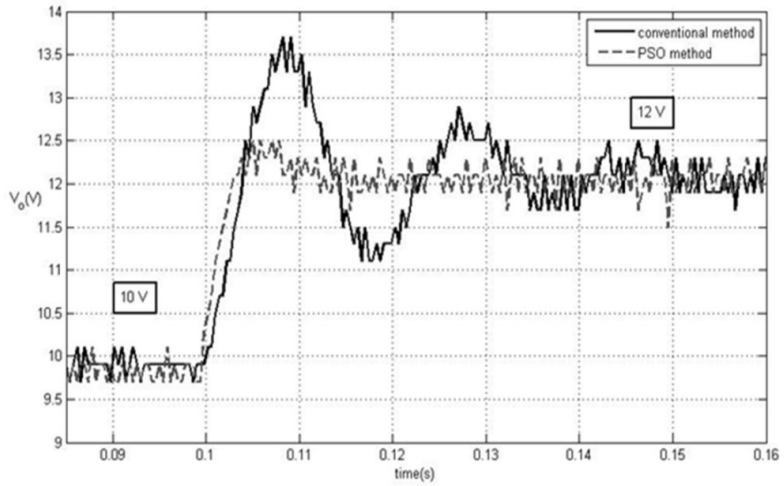


Figure 17: The experimental results of v_o for changing the v_o^* from 10 V to 14 V

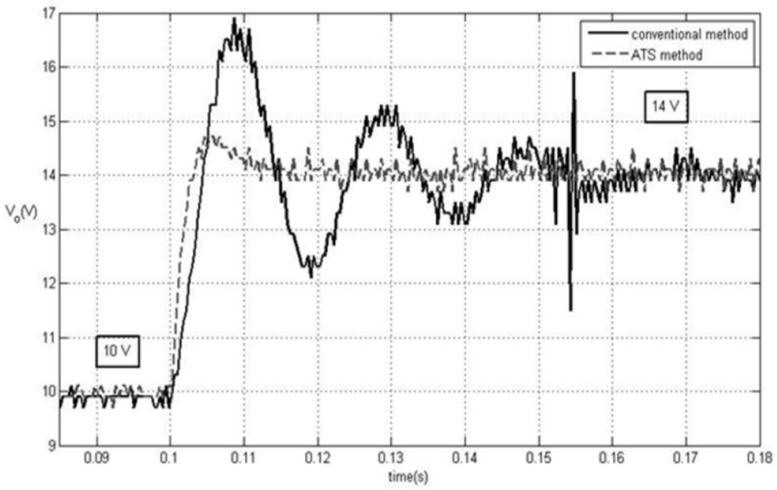


Figure 18: The experimental results of v_o for changing the v_o^* from 10 V to 14 V

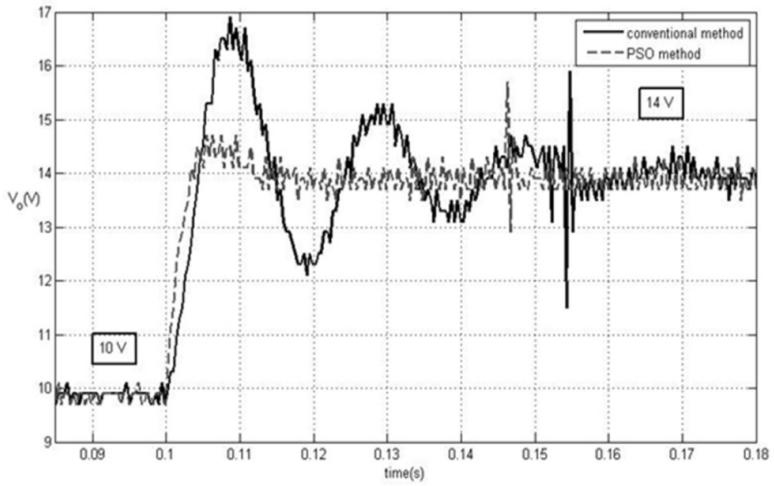


Figure 19: The experimental results of v_o for changing the v_o^* from 10 V to 16 V

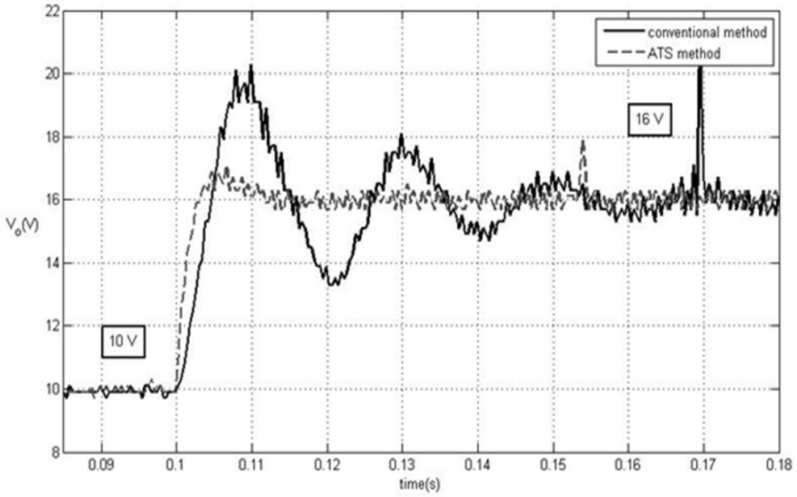
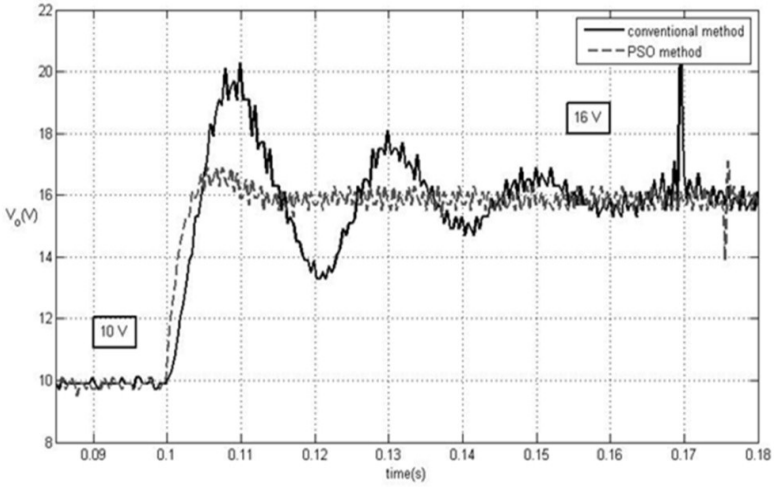


Figure 20: The experimental results of vo for changing the v_o^* from 10 V to 16 V



The comparison results from the simulation and experiment show that the output responses when the controllers designed by the ATS and PSO methods are better than that from the conventional method in terms of percent overshoot, rise time and setting time under the changing of command input.

6. Conclusion

The paper presents the cooperation between the averaging model derived from the GSSA method and the AI methods called the ATS and PSO algorithms to design the appropriate cascade PI controller parameters of the buck converter. The resulting output responses using the ATS and PSO designs are better than that of the conventional method for variations in command input. Moreover, the paper also show that the simulation of the switching converter system using the averaging model consumes the faster computational time compared with the simulation time of the exact topology model from the software package. The eigenvalue of the system can be also calculated via the proposed averaging model for the stability analysis during the searching process. Hence, the reported dynamic model is suitable for the optimal controller design application in which the repeating calculation during the searching process is needed. In the paper, the experimental results from the testing rig are used to

support the simulation results. The results shows that the proposed design technique is very useful for engineers and it can provide the best output performance with the stable operation confirmation. The concept of the optimal design for the buck converter using the AI methods described in the paper can be applied to other converters such as boost converters, buck-boost converters, and cuk converters. The GSSA method can be also used to derive the averaging model of these DC/DC converters in which the work of this paper show that the GSSA averaging model is suitable for the optimal design using the AI techniques.

Acknowledgments

This work was supported by Suranaree University of Technology (SUT) and by the office of the Higher Education Commission under NRU project of Thailand.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.354-366
http://www.europeanjournalofscientificresearch.com

Individual-, Household-, and Community-Level Determinants of Poverty in Seoul, Korea: Findings from a Logistic Regression Model

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Abstract

The purpose of this paper is to analyse the effects of individual-, household-, and community-level characteristics on poverty status in Seoul, Korea. We used data from the Korean Labour and Income Panel Study, the 2005 Population and Housing Census, and the 2005 Local Government Budget. The units of analysis are 745 households in 25 districts in Seoul. We investigated the spatial distribution of poverty-related characteristics by employing exploratory spatial data analysis techniques and examined the influence of individual-, household-, and community-level characteristics on poverty status using a logistic regression model. According to our results, older householders and households headed by females have a higher probability of entering poverty. As the exposure index increases, the probability of a household entering poverty decreases. These results may have policy implications for neighbourhood and community development and suggest that local governments should consider the spatial dimensions of poverty when establishing anti-poverty policies.

Keywords: Poverty, Exploratory Spatial Data Analysis, Logistic Regression Model

1. Introduction

Poverty is one of the most prevalent and pervasive social problems in developed and developing countries. After the Asian economic crisis in 1999 and the global financial crisis in 2008, the income gap among the various regions in Korea increased, and people have become more concerned with poverty. Both central and local governments recognize the seriousness of poverty and have attempted to solve the problem through poverty-related policies. Thus far, these policies have focused on individual circumstances. The local government has provided grants to residents who live in poverty with an income below a standard level through the National Basic Livelihood Security System. Although people who live in poverty have been provided with a self-support program, the poverty gap remains.

At the local level, Seoul has implemented various policies, such as urban regeneration and housing improvement, to improve the residential neighborhood environment. Although Seoul has invested considerable time and money in these policies, the quality of life of urban residents in Seoul has deteriorated because of residential segregation between income classes and social exclusion. Although older disadvantaged public housing has been replaced with new public rental housing, serious problems remain, including the polarization of residential neighborhoods among income groups and place stratification. This problem has become especially prevalent in some areas (Bae and Joen, 2006).

Poverty-stricken households in urban areas are concentrated in specific regions as a result of residential segregation and place stratification. These regions are likely to have more disadvantages than other regions. For example, residents have fewer opportunities and a decreased desire to escape poverty, and they are more frequently exposed to relative deprivation as a result of the negative externalities of the neighborhood. Therefore, poverty policies are established for individuals and are based on location. This study analyzes the effects of individual and household characteristics on household poverty. Furthermore, this study analyzes household poverty with a focus on the community-level characteristics that increase the likelihood of entering poverty status. This paper addresses the following two specific questions: (i) to what extent are disadvantaged people segregated in each district in Seoul, and (ii) how do individual, household, and community-level characteristics affect the poverty status of households?

This study is organized into four remaining sections. Section 2 addresses relevant previous studies that are based on a variety of poverty determinants. Section 3 introduces exploratory spatial data analysis (ESDA) techniques and a logistic regression model. In Section 4, the empirical results of our analysis are presented. This paper closes with a summary and concluding remarks in Section 5.

2. Literature Review

2.1. The Effects of Individual and Household Characteristics on Poverty Status

The primary causes of poverty in households are individual and household characteristics. Gender, age, race, educational level, and the occupational statuses of heads of households are the main variables in this analysis (Bane and Ellwood, 1986; Iceland, 1997; Stevens, 1999; Ku, 2002; Hong, 2004; Kim and Noh, 2009). Using data from the Panel Study of Income Dynamics (PSID) to measure the duration of poverty, Bane and Ellwood (1986) studied the dynamics and duration of poverty (or poverty spells) and found that poverty as measured by the incomes of heads of households is determined by the length of time that impoverished people remain in poverty. Stevens (1999) investigated the duration of poverty through multiple spells and even considered poor people who escaped poverty but later re-entered poverty using the discrete-time hazard model approach. The poverty line was based on the criteria of the U.S. Census Bureau and on household income levels based on the size of households. Stevens insisted that the probability of re-entering poverty must be considered with regard to the research because the amount of time that an individual spends in poverty influences the actual duration of poverty. The analysis shows that approximately half of the households that escape poverty return to poverty within four years, and 50% of blacks and 30% of whites appear to remain in poverty for five to ten years.

Hong (2004) determined the poverty cycle for individuals using the five-year Korean Labor and Income Panel Study (KLIPS) data and analyzed the influence of employment status on poverty using a hierarchical and discrete-time hazard analyses of the escape rate. Hong (2004) found that the onset of poverty is closely related to whether householders are employed and the quality of work. Kim and Ban (2004) studied how employment insecurity and the experience of poverty after an economic crisis affect the implementation of poverty (poverty entry and poverty escape) and confirmed that the human capital of a household header has an important influence on the implementation of poverty. Heads of

households with unstable employment and those with prior experience of poverty were more likely to re-enter poverty. Women, the elderly, and individuals with poor educational backgrounds who are household headers are more likely to enter into poverty, and maintaining a stable employment status was an important variable in the implementation of poverty.

The state dependence effect states that households that have experienced poverty in the past are more likely to experience poverty in the future. Seok (2007) has verified the effects of state dependence on the maintenance of poverty. As demonstrated by the results of the study by Stevens (1999), some of the households that had escaped poverty re-entered into poverty. Even if a household is not currently impoverished, prior experience with poverty may increase the risk of re-entering poverty in the future. Using the dynamic random-effects probit model and the dynamic conditional logit model, Seok (2007) verified that the possibility of entering poverty in the future is to the result of personal characteristics or past poverty experiences. This author provided evidence of the state dependence between past experiences and future entry into poverty, and the structural relationship emphasized the importance of the early prevention of poverty. Based on this research, we consider state dependence to be a household characteristic, and we analyze its influence on entering poverty in this study.

2.2. The Effects of Community-Level Characteristics on Poverty Status

A regional approach to poverty does not consider how the influence of household characteristics on poverty differs in various socio-economic contexts and environments (Brown and Hirschl, 1995). Many studies have analyzed poverty by using the regional socio-economic environment, such as the economic level of a region, the financial characteristics of a local government (e.g., financial independence, taxes, income level), employment growth, unemployment rates, public assistance recipients in an area, and the proportion of female household headers (Brown and Hirschl, 1995; Keum and Kim, 2001; Blank, 2005; Song, 2007; Kim and Noh, 2009; Milbourne, 2010).

Blank (2005) emphasized that both place-based and people-based views are necessary to study the poverty gap in a region, and he attempted to conduct qualitative studies of the regional characteristics that affect poverty by considering the natural environment, the economic structure, public and private institutions, social norms, and demographic characteristics. This endeavor led to an in-depth study on poverty for each regional feature with implications on policies that target households. Milbourne (2010) focused on poverty and welfare from a geographic perspective by investigating spatial disparities, the persistence of poverty, relationship between poverty and location in the context of geographic regions, and the reestablishment of relationships between the central government and the local welfare system. Milbourne (2010) found that poverty can be caused by the spatial concentration of poor people in urban areas. Poverty research in the spatial context and anti-poverty policies based on location are necessary to ensure that the provision of social support networks is relatively equal to reduce the spatial imbalance. The studies of Blank (2005) and Milbourne (2010) are important in demonstrating how regional characteristics are related to poverty in qualitative studies. Therefore, we must statistically verify the extent to which regional characteristics can influence a household's poverty status using quantitative studies.

Keum and Kim (2001) analyzed the dynamic process of poverty implementation using KLIPS data. With regard to residential areas, the likelihood of an individual within a particular city or district to enter poverty was statistically significant. However, a household’s presence in such a region did not necessarily cause entry into poverty. Thus, further research regarding regional characteristics with respect to poverty is needed. Kim and Noh (2009) have verified the influence of duration and escape from poverty at the individual and regional levels simultaneously. In that study, the authors emphasized that the social and economic structure is as crucial to the causes of poverty as are individual characteristics, and they used a hierarchical generalized linear model to analyze the influence of these variables at the individual and regional levels with respect to the duration of and escape from poverty. When the householders demonstrated certain characteristics (e.g., they were

women, elderly, of a lower educational level, or in an unstable form of employment), the probability of escaping the long duration was found to be lower. Although these studies considered regional factors by reflecting on the characteristics of the economy and society, there was no practical significance with regard to how the characteristics of these areas influenced individuals because the spatial extent was too extensive.

2.3. The Spatial Dimension of Neighborhood Poverty

We reviewed previous studies that focused on the spatial characteristics of regions and sought studies that have addressed more practical spatial characteristics rather than less practical macro characteristics. The studies on regional spatial characteristics suggested that a variety of criteria and measurement indicators can assess the spatial segregation of social classes, and several researchers have established concepts and compared these indicators (Massey and Denton, 1988; Reardon and O'Sullivan, 2004; Bae and Jeon, 2006; Lee, 2007). These studies employed various effective descriptions of the spatial characteristics of neighborhoods, but such definitions differed only in terms of geography.

Bae and Jeon (2006) studied the spatial distribution and segregation patterns of low-income housing in Seoul. These authors focused on spatial segregation, social exclusion, and residential polarization between classes rather than the dynamic properties of poverty. Iceland, Sharpe, and Steinmetz (2005) analyzed the dissimilarity index and the isolation index for racial and ethnic residential segregation. The study by Ross and Mirowsky (2001) also pertained to racial residential segregation and the disadvantages of poverty at the neighborhood level. These studies are related to poverty, but they identified spatial characteristics only in terms of geography.

Iceland (1997) reviewed economic restructuring, skill mismatches, and the welfare benefit levels that affect the escape from poverty of residents in metropolitan areas. He used neighborhood characteristics, such as the employment rates for the manufacturing, service, and retail sectors; the degree of racial residential segregation according to the dissimilarity index; and the proportion of the population with high school diplomas. The results of the analysis of the logistic regression model revealed that the poverty escape of residents affected both the rate of employment change in the manufacturing sector and racial residential segregation. However, this poverty study reflects only regional characteristics in the U.S. It is necessary to research poverty-related studies both at the individual and household levels and at the regional characteristic level in Korea with reference to this study.

3. Research Methods

3.1. Exploratory Spatial Data Analysis Techniques

ESDA is an analytical method that is used to obtain sufficient information from existing data. We can interpret data and regional characteristics and reflect on this study using a variety of methods. The most widely used index of residential evenness is the dissimilarity index, which measures the departure from evenness by taking the weighted mean absolute deviation of every unit's minority proportion of the city's minority proportion and expressing this quantity as a proportion of its theoretical maximum (Duncan and Duncan, 1955). The dissimilarity index can be written as follows:

$$D = \frac{1}{2}\sum_{i}^{n}\left|\frac{x_i}{X} - \frac{y_i}{Y}\right|, \tag{1}$$

where i is a unit of area (*dong* level), x_i and y_i are two separate groups in i. This index varies between 0 and 1 and can be interpreted such that a value closer to 0 will be evenly distributed and a value closer to 1 will have a high degree of uneven distribution. In this study, the X set represents a disadvantaged group.

We will also use the exposure index for the degree of potential contacts within a region or for the probability of interrelationships among disadvantaged groups. The exposure index is found to be more suitable than the dissimilarity index to reflect the experience of segregation and the relative group size. The exposure index measures the extent to which members of minority group X are exposed to members of majority group Y (Massy and Denton, 1988). This index determines the minority-weighted average of each spatial unit's majority proportion, and the formula is as follows:

$$ {}_xP_y^* = \sum_{i=1}^{n}\left(\frac{x_i}{X}\right)\left(\frac{y_i}{t_i}\right), \tag{2}$$

where x_i and y_i are the number of group X members and Y members in unit i, respectively, and t_i is the total population of unit i. X represents the number of X members district-wide. As in the dissimilarity index, X refers to a disadvantaged group.

Spatial autocorrelation can be defined as the coincidence of value similarity with locational similarity (Anselin and Bera 1998). Positive spatial autocorrelation occurs when similar values for a variable are clustered together, and negative spatial autocorrelation appears when dissimilar values are clustered in space. Several indexes have been proposed in the spatial data analysis literature to assess the presence of spatial autocorrelation. This study employs the Moran's I statistic, which is the most widely known measure of spatial autocorrelation. Formally, the Moran's I statistic is expressed as:

$$ I = \left(\frac{n}{s_0}\right)\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}x_i x_j}{\sum_{i=1}^{n} x_i^2}, \tag{3}$$

where n is the number of observations, w_{ij} is the element in a spatial weights matrix corresponding to the regions (i, j), the observations x_i and x_j are in deviations from the mean of a variable for regions i and j, respectively, and s_0 is a normalizing factor equal to the sum of the elements of the weights matrix, i.e., $s_0 = \Sigma_i\Sigma_j\, w_{ij}$. The value of Moran's I statistic ranges from –1 for negative spatial autocorrelation to 1 for positive spatial autocorrelation. Over the entire geographic units, if similar values are more likely than dissimilar values between neighbors, the Moran's I statistic tends to be positive, and vice versa.

To identify local spatial clusters, we use a local indicator of spatial association (LISA). The local Moran's I statistic for each neighborhood i can be defined as follows:

$$ I_i = \left(\frac{x_i}{m_0}\right)\sum_j w_{ij}x_j\ , \tag{4}$$

where $m_0 = \Sigma_i\, x_i^2 / n$, and the summation over j is such that only neighboring values of j are included. A positive value for I_i indicates the spatial clustering of similar values, whereas a negative value indicates the spatial clustering of dissimilar values between a geographic area and its neighboring areas. The local Moran's I statistic can be visualized in the form of a LISA cluster map that depicts the locations of significant local Moran's I statistics and is classified by the type of spatial association. The four types of local spatial associations between a geographic area and its neighbors are (i) HH: high-high association (high values surrounded by high values), (ii) LH: low-high association (low values surrounded by high values), (iii) LL: low-low association (low values surrounded by low values), and (iv) HL: high-low association (high values surrounded by low values).

3.2. Logistic Regression Model

In this study, we employ the poverty entry model to examine whether a non-poverty household in t-1 year maintains the same status in t years. This value is coded as 1 if a household that experienced non-poverty in t-1 year entered poverty in t years and is coded as 0 if a household that experienced non-

poverty in *t*-1 year remains a non-poverty household in *t* years. We will apply the logistic regression model as described below.

$$p = \frac{\exp(\beta_0 + \beta_1 X)}{1 + \exp(\beta_0 + \beta_1 X)}, \tag{5}$$

If the probability when the range of dependent variables is 1 is denoted as *p*, then the logistic regression model is a deformed logistic function of explanatory variable *X*. The linear form model is employed through a logistic transformation rather than the probability *p*. The transformed basic model is as follows:

$$Y = \ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1 X . \tag{6}$$

To apply the basic model, we will analyze the effects of both individual and household characteristics *X* and community-level characteristics *Z* on poverty status using the logistic regression model:

$$Y = \ln\left[\frac{p}{1-p}\right] = \beta_0 + \sum \beta_j X_j + \sum \gamma_k Z_k + \varepsilon . \tag{7}$$

4. Empirical Results

4.1. Data and Variables

To ensure consistency with most other empirical studies that analyze poverty, this study uses 519 dong areas in 25 districts in Seoul. Household data are obtained from the KLIPS data from 2004 to 2007. To analyze the information that is used for the analysis, we used a total sample size of 745 households. Data for the community-level characteristics were obtained from the 2005 Population and Housing Census, the 2005 Local Government Budget, and the Seoul Statistics Annual Report from 2005.

Poverty refers to the lack of basic human needs, such as clean water, nutrition, health care, education, clothing, and shelter because of one's inability to afford them. Poverty is defined by various complexities and changes depending on the time and social surroundings. The general definition can be divided into absolute poverty, which is the lack of basic survival needs, and relative poverty, which is based on the comparative standard of living in a society. In this study, the definition of poverty is pecuniary in that the average income of households is below the poverty line as estimated by the living standards of the general society. In Korea, public assistance recipients fall below the poverty line and are considered to be the most disadvantaged; their "sum of income recognition" is below the minimum cost of living, and they receive government assistance. Public assistance recipients are those who are eligible to receive government subsidies from the National Basic Livelihood Security Act without any supporting obligor or with an obligor who is unable to provide support.

The establishment of a standard to determine poverty is important when studying poverty. In this study, poverty is determined by household income. In this monetary approach, the poverty line can be a criterion to confirm whether a household is impoverished. Based on the estimated poverty line, poverty and non-poverty can be distinguished, and the methods of determining the poverty line are divided into those that determine the absolute and relative poverty lines. The absolute poverty line is estimated by the cost of basic survival needs based on household size in Korea. The cost of basic survival needs refers to the minimum cost that is required to maintain the health and cultural life of people and is announced each year by the Ministry of Health. The cost of basic survival is useful in determining the criteria for the government supplemental compensation system because it is obtained by converting the minimum amount of all necessary items for human life into a monetary value. The relative poverty line is estimated by the income level of the members of society as a whole. The mean income or the constant rate of expenditure is used as a standard given the income distribution.

Households below the poverty line are believed to be living at a standard of living that is inferior to that enjoyed by the majority of society.

Poverty line levels are set differently by various agencies and researchers. The World Bank has established the poverty line at one third of the average household income in developing countries and a half of the average household income in developed countries. The minimum poverty line is 50% of the average income in the EU and 40%, 50%, or 60% of the median income in OECD countries, and the Korea Institute of Health and Social Affairs reported that the OECD standards are appropriate for Korea. The absolute poverty line is the minimum cost of living and reflects a country's inflation rate, which is suitable only for studies that investigate countries in which inflation does not vary greatly. Relative poverty can be used to measure household configuration by calculating the real income or expenditure distribution of a population. In this study, we reference the study by Hong (2004) and use an absolute poverty line but adjust this poverty line using the underreporting problem of income from the KLIPS data. In this study, 40% of the income is linked to the poverty line in the sense that the lowest income per household size published by the government ranged from 38.3% to 44.7% of the median income that is estimated in the data.

The prescribed types of income are also important in determining whether a household is impoverished. According to previous studies, gross income is considered to be the most relevant indicator in analyzing the implementation of poverty; thus, we select gross income as the basis of income (Ku, 2002). Gross income is the sum of both ordinary and extraordinary income. We deducted the annual gross income of the households by adding earned and financial income, property income, and transfer income from the KLIPS data.

The degree of financial self-support as a general and financial characteristic of a region refers to financial ratios of the total budget of the local government in the region. Most of the districts have a low degree of financial self-support with the exception of several districts in Seoul. Social development expenditures as a budget item are spent on housing, health, culture, workforce development, and social welfare. Using the amount of expenditures per capita for each district, we analyze the probability of poverty entry depending on financial characteristics and investment over the life of the residents in the region.

4.3. Exploratory Spatial Data Analysis

We analyzed the distinctive ratio of the disadvantaged groups to investigate their basic status with ESDA. We also analyzed the dissimilarity and exposure indices at the community (*dong*) level to examine the distributional features of the disadvantages. Spatial distribution and clustering levels were analyzed through the spatial characteristics of the region using the local Moran's I statistic and the LISA map.

The concentration of disadvantaged groups is represented by a dissimilarity index (Table 1). The dissimilarity index of each district is derived from data pertaining to communities in Seoul. The uneven distribution of public assistance recipients is prevalent in Gangnam-gu, Gangseo-gu, and Seocho-gu in decreasing order. In Geumcheon-gu, Sungbuk-gu, and Gwangjin-gu, public assistance is distributed evenly. Regardless of their number, if disadvantaged group members are concentrated in a specific neighborhood, then the district in which such a neighborhood is located appears to be uneven. A map that is based on the dissimilarity index of public assistance recipients is shown in Figure 1. Public assistance recipients displayed a higher exposure index in Dobong-gu, Yangchun-gu, Dongjak-gu, Gwangjin-gu, Songpa-gu, and Gangdong-gu, and the exposure index in Gangnam-gu was relatively low compared with non-recipients. Figure 1 details the dissimilarity and exposure indices, and the specific values for these indices are presented in Table 1.

Table 1: Dissimilarity and exposure indices

No	Districts	Dissimilarity index	Exposure index
1	Jongno-gu	0.2916	0.9693
2	Jung-gu	0.1723	0.9680
3	Yongsan-gu	0.2953	0.9701
4	Seongdong-gu	0.1807	0.9762
5	Gwangjin-gu	0.1677	0.9869
6	Dongdaemun-gu	0.1785	0.9781
7	Jungnang-gu	0.2315	0.9687
8	Seongbuk-gu	0.1462	0.9818
9	Gangbuk-gu	0.2530	0.9618
10	Dobong-gu	0.2638	0.9843
11	Nowon-gu	0.4286	0.9186
12	Eunpyeong-gu	0.2597	0.9594
13	Seodaemun-gu	0.2112	0.9818
14	Mapo-gu	0.2828	0.9756
15	Yangcheon-gu	0.2615	0.9825
16	Gangseo-gu	0.5509	0.8974
17	Guro-gu	0.2962	0.9731
18	Geumchun-gu	0.1287	0.9735
19	Yeongdeungpo-gu	0.2534	0.9737
20	Dongjak-gu	0.1959	0.9829
21	Gwanak-gu	0.2024	0.9781
22	Seocho-gu	0.4771	0.9724
23	Gangnam-gu	0.6447	0.8958
24	Songpa-gu	0.2492	0.9878
25	Gangdong-gu	0.2586	0.9851

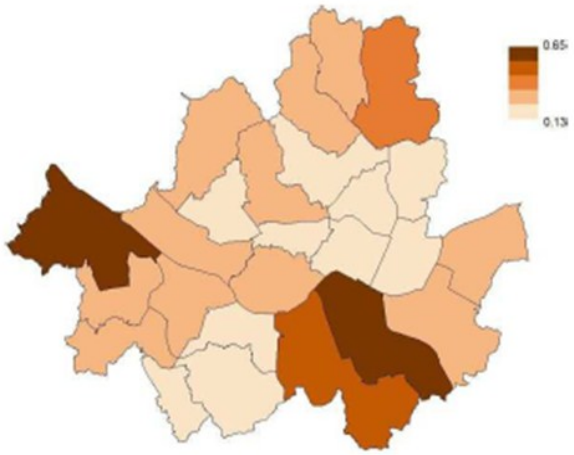
The LISA map that is based on the local Moran's *I* statistic of communities is shown in Figure 1(c). The High-High type of public assistance recipient is found in some parts of Seongbuk-gu, Nowon-gu, Jung-gu, and Gangnam-gu, and the Low-Low type is found in some parts of Seocho-gu, Gangnam-gu, Songpa-gu, Gangdong-gu, Yangcheon-gu, and Mapo-gu. The disadvantaged are found at a high rate in areas in which public rental apartments have been established and at a low rate in areas in which primarily middle- or upper-middle-class residents reside. The LISA map based on the local Moran's I index of communities shows that public assistance recipients tend to spatially cluster in communities in Gangbuk-gu, Dobong-gu, Nowon-gu, and the most southern part of Gangnam-gu.

4.4. Logistic Regression Analysis

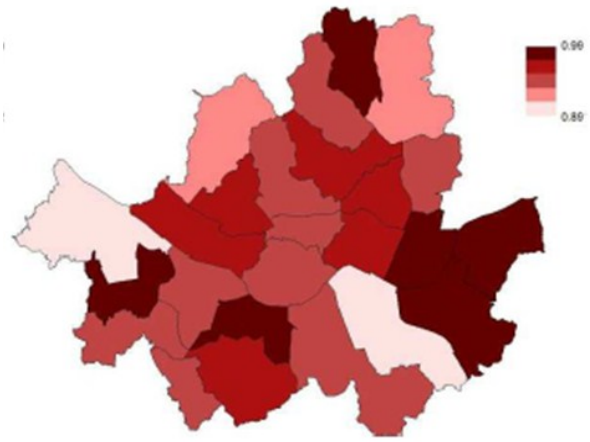
Household data were obtained from KLIPS data from 2004 to 2007. Using these data, we determined that the dependent variable was the poverty status change and whether a non-poverty household in 2005 maintained this status until 2006. The independent variables are composed of the individual characteristics of households. The poverty status in 2004 verified the state dependence effect and the general spatial characteristics of the region. The disadvantaged groups that were used to analyze the spatial characteristics included public assistance recipients. The descriptive statistics for the variables that were used in the regression are shown in Table 2. Poverty status is denoted by binary variables that refer to either remaining in non-poverty (0) or entering poverty (1). Households that entered poverty constitute approximately 7% of the target analysis. The average number of household members is approximately 3.32 people, and 85% of all householders are male. Householders had completed an average of 12.24 years of education. In 2004, 6% of all target households were impoverished. Some households did not appear to be impoverished in 2005 but re-entered poverty in 2006. The degree of financial self-support of regional characteristics appears to range from 29.1% to 92.6%, with an average value of 49.7%. The local governments of the district spent from 163,000 won to 479,000 won

on social development. Public assistance recipients constituted approximately 18% of the total population in Seoul and have exposure index values that range from 0.898 to 0.988. The target households living in Low-Low types of LISA are approximately 8% of all households.

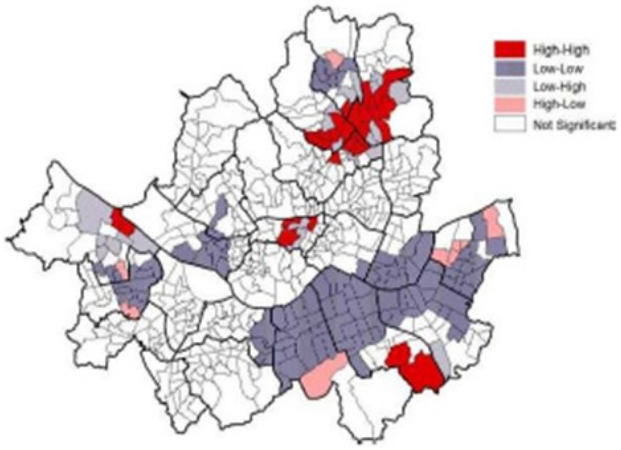
Figure 1: Exploratory spatial data analysis maps



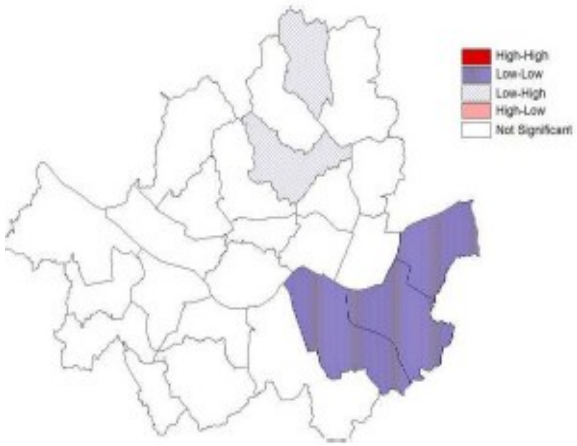
(a) The dissimilarity of disadvantaged groups



(b) The exposure of disadvantaged groups



(c) LISA map of disadvantaged groups (*dong*)



(d) LISA map of disadvantaged groups (*gu*)

Table 2: Descriptive statistics

Variables		*N*	Min	Max	Mean	Std Dev
Poverty status (poverty=1)	POV	745	0	1	0.070	0.255
Number of household members	NHM	745	1	7	3.320	1.222
Gender of householder (male=1)	GEN	745	0	1	0.850	0.362
Age of householder	AGE	745	24	87	48.970	12.542
Years of schooling of household head	EDU	745	0	23	12.240	3.659
State dependence effect (poverty in 2004=1)	DEP	745	0	1	0.060	0.246
Degree of financial self-support	FIN	25	0.291	0.926	0.497	0.199
Social development expenditure per capita	SOC	25	0.163	0.479	0.241	0.070
Public assistance recipient exposure	EXP	25	0.896	0.988	0.969	0.020
LISA Low-Low type	LISA	25	0	1.000	0.080	0.264

Table 3: Logistic regression results

Variables	Model [1]	Model [2]	Model [3]	Model [4]
Individual and household characteristics				
NHM	– 0.426 *** (0.137)	– 0.438 *** (0.138)	– 0.401 *** (0.138)	– 0.415 *** (0.139)
GEN	– 0.762 ** (0.354)	– 0.783 ** (0.355)	– 0.798 ** (0.356)	– 0.829 ** (0.358)
AGE	0.037 *** (0.013)	0.037 *** (0.013)	0.035 *** (0.013)	0.036 *** (0.013)
EDU	– 0.056 (0.045)	– 0.053 (0.045)	– 0.057 (0.045)	– 0.050 (0.046)
DEP	1.339 *** (0.400)	1.328 *** (0.404)	1.434 *** (0.410)	1.426 *** (0.416)
Community-level characteristics				
FIN		– 0.303 (0.874)		0.351 (0.920)
SOC		– 3.105 (2.848)		– 5.156 (3.151)
EXP			– 14.778 ** (6.371)	– 16.102 ** (6.351)
LISA			– 0.550 (0.690)	– 0.770 (0.724)
Constant	– 2.216 (1.059)	– 1.331 (1.261)	12.116 * (6.235)	14.406 ** (6.293)

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3 presents the results of the logistic regression model. In Model [1], the results of the logistic regression analysis using the variables of household characteristics are identical to those of previous empirical studies of poverty and household characteristics. The probability of entering poverty is high for small households or for households with elderly or female householders. Households that have experienced poverty in the past have a high probability of re-entering poverty. However, the education level of householders does not significantly affect poverty entry because education level does not appear to reflect the quality of education. The results of the variables of regional characteristics were classified into three types. According to the results of Model [2], the effects of individual characteristics appear indifferent to Model [1]. The general characteristics of regions as the degree of financial self-support and social development expenditures per capita do not yield any statistically significant results. The results of Model [3] show that as the exposure index increases, the probability of poverty entry tends to decrease. Thus, when disadvantaged groups are more exposed to the other group, the probability of poverty entry is lower. Model [4] is analyzed using all of the variables of individual and regional characteristics. The results of Model [4] present few differences from the previous models and show that poverty entry is affected by a number of variables, including the gender, age, and poverty experience of a householder and the degree of exposure of a disadvantaged group. We expected that poverty entry would be more likely to occur when householders had lower levels of education or when the region had a lower degree of financial self-support and social development expenditures per capita (from the general characteristics of the region). However, the results did not support our hypotheses.

Considering the results of the logistic regression analysis, we can conclude that household poverty status is affected by individual characteristics, such as the number of household members and the gender and age of householders, as shown by previous studies. A household that experienced poverty in the past is likely to enter poverty again; thus, the state dependence effect is proven. Moreover, we also found that the exposure index of community-level characteristics is a factor that considerably affects poverty status at the household level. Based on the community-level

characteristics that were used in this study compared with those that were examined in previous research, as disadvantaged households become more exposed to and less isolated from other groups, the probability of a household entering poverty decreases. Given our significant results that the possibility of entering poverty is lowered when disadvantaged groups have greater exposure to others, we are able to confirm the hypothesis that spatial characteristics may affect whether households enter poverty and present the policy implications of urban poverty based on regional characteristics.

5. Conclusions

The purpose of this study was to analyze the probability of entering poverty for the 25 districts in Seoul according to the characteristics of individuals and regions. The spatial units in this study are imposed for ease of analysis and for presenting the need for more effective and realistic policies to address poverty with respect to the spatial characteristics of neighborhoods in Seoul. The empirical results revealed that the community-level characteristics that are derived from the ESDA differed by region. Public assistance recipients were concentrated in specific regions of Seoul. The dissimilarity and exposure index results show a residential segregation phenomenon among residents. The results of the analysis of the LISA map at the community- level drawn by the local Moran's *I* index also suggests that disadvantages are spatially clustered in specific areas

Considering the results of the logistic regression analysis, we reached a conclusion that is similar to those of previous studies: the status of household poverty is influenced by individual characteristics, such as the number of household members, the gender and age of householders, and poverty experience (the state dependence effect). Moreover, we find that the exposure index for community characteristics is a factor that considerably affects poverty status at the household level. With regard to these community characteristics, the disadvantaged households were less exposed to other people and more isolated; thus, their risk of entering poverty was increased. Negative regional effects stemming from residential segregation appear to significantly affect the probability of entering poverty; hence, governments should consider regional characteristics when establishing anti-poverty policies.

In the analysis above, we hypothesized that a household entering poverty would be influenced by community-level characteristics. The policy implications of this study are as follows: governments should recognize that neighborhoods and their surrounding environments can affect the probability with which households enter into poverty, when establishing poverty-related policies, governments should provide a complementary policy at the neighborhood and regional levels to support poor people in particularly congested area,; and governments should consider poverty solutions that aim to both improve individual levels of human capital and the family structure and induce diversity within residential areas and basic welfare at the community level. In addition to increasing employment opportunities for individual households, improving property levels for individuals, and reforming the family structure, local governments must improve the opportunity structure and expand appropriate welfare services and rehabilitation assistance programs at the neighborhood and regional levels by targeting disadvantaged groups across the area. Furthermore, with regard to current public assistance and rehabilitation programs for individuals, it is necessary to induce harmony in the social hierarchy, improve the physical environment to integrate residents in social and economic ways, and organize various programs and networks for local residents.

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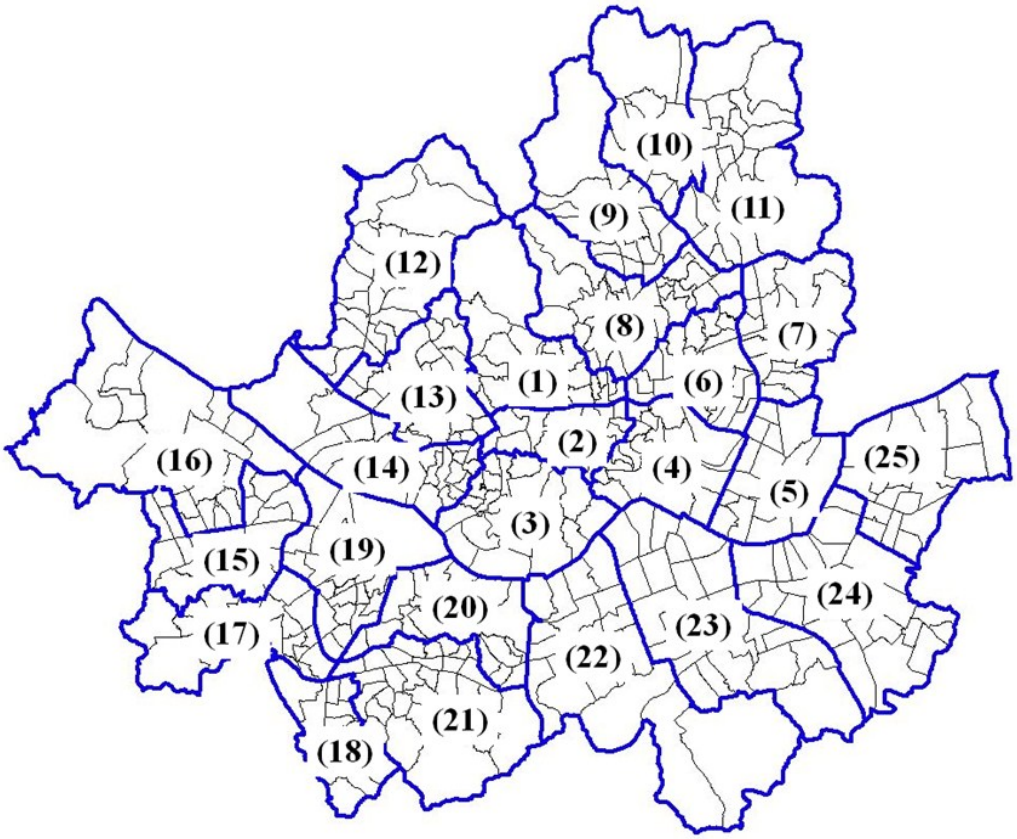
Appendix

Figure A: 25 districts in Seoul



(1) Jongno, (2) Jung, (3) Yongsan, (4) Seongdong, (5) Gwangjin, (6) Dongdaemun, (7) Jungnang, (8) Seongbuk, (9) Gangbuk, (10) Dobong, (11) Nowon, (12) Eunpyeong, (13) Seodaemun, (14) Mapo, (15) Yangcheon, (16) Gangseo, (17) Guro, (18) Geumcheon, (19) Yeongdeungpo, (20) Dongjak, (21) Gwanak, (22) Seocho, (23) Gangnam, (24) Songpa, (25) Gangdong

European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.367-372
http://www.europeanjournalofscientificresearch.com

The Effect of Emotional Intelligence Training via Method Psychodrama on Marital Satisfaction of Patients with MS

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Abstract

MS is a progressive and chronic disease of the central nervous system with symptoms that can be debilitating. Appropriate interventions including Emotional Intelligence Training improve the quality of life MS patients. The aim of this study is to determine the effect of emotional intelligence training through Psycho-Drama methods on marital satisfaction of patients with MS. This study is a one-group, before-after, quasi-experimental study. A total of 22 patients were enrolled in this study. The samples were selected through non-random sampling based on the goal of study among visitors of MS Society, Kurdistan province, Iran. Data collection tool was questionnaires with two sections: 1) demographic information and 2) ENRICH-B marital satisfaction questionnaire including 47 items. Intervention was conducting 20 sessions of 2-hour training. Questionnaires were filled by patients before and after intervention. Methods for data analysis were descriptive statistics (tables of relative frequency distribution, the mean, and standard deviation) and inferential statistics of paired t test. Paired t test showed a significant difference in total scores of marital satisfaction before and after training sessions ($P < 0.05$). Finally, we concluded that, designing and applying emotional intelligence training programs via psychodrama method is effective on marital satisfaction in patients with multiple sclerosis.

Keywords: Multiple sclerosis, emotional intelligence training, psychodrama, marital satisfaction

1. Introduction

MS is the most common disabling disease of young adults that occurs due to demyelinating inflammatory process in central nervous system. MS is the third most common cause of disability in people aged 20 to 40 years and two and a half million people worldwide are infected with the disease. In Iran, there are about forty thousand patients with MS among which, 12 thousand patients currently have listed in the MS Community. In Iran, its outbreak rate is approximately 20 cases per hundred thousand people. It affects all aspects of human's life (Sahebalzamani et al. 2012) as well as quality of relationship of the couples. Studies have been shown that, abilities and emotional intelligence are among the influencing factors on the quality of marital relationships (Lopes et al., 2003, Haijbregts et al., 2006, Salovey et al., 2002). Emotional intelligence refers to the ability to perceive, understand and manage emotions in self and others (Extremera et al., 2006). Emotional intelligence involves the individual differences in terms of emotional capabilities both internal (stress management) and interpersonal (understanding the emotions of others) (Saklofske et al., 2007). Compared to the traditional IQ measures, EQ is a better predictor of success and social adjustment so that, people with higher EQ have better ability to cope with stresses and to improve their interpersonal relationships (Mohammad Khani and Bash Ghareh, 1387). Since that, a satisfied marriage is an appropriate background for better exchange of emotions and positive feelings between couples, using methods such as EQ to promote emotional intelligence is necessary. Researchers like Clark, Fitness and Brist argue that, individuals with higher levels of emotional intelligence than those with lower emotional intelligence, experience greater marital satisfaction and have higher ability to understand and accept the thoughts, emotions and a mutual relations of marital life that associated with greater satisfaction. Therefore, using a variety of EQ methods and techniques is effective on improving relationships between married couples and reducing conflicts (Tirgari et al., 1385). To prove this, Mhaniyan Khamene (1385) investigated the relationship between emotional intelligence and marital satisfaction on 240 female teacher and concluded that, there is a correlation between emotional intelligence and its components with marital satisfaction ($p<0.001$) (Mhaniyan, 1385). Furthermore, various studies confirmed the effect of marital satisfaction on professional, educational, and social performance (Tirgari et al., 1385). Emotional intelligence encompasses a broad range of training including psychodrama. Psychodrama is a treatment in which, the therapist helps patients through different drama methods benefiting, puppetry, theatre, and pantomime to help them recognize the aspects of their life and correct their behavior and speech (Amraiy, 1389). Concerning the above, and due to the importance of marital satisfaction from one hand, and the acquiring nature of emotional intelligence and the role of the EQ training on improving couples' relationships from the other hand, the authors have tried to investigate the effect of emotional intelligence training, via psychodrama, on marital satisfaction.

2. Methodology and Data

The study is a one-group quasi-experimental study so that, a group was subjected to independent variable, emotional intelligence training through psychodrama. Then, the marital satisfaction scores before and after conducting training was compared. The statistical population consisted of patients with multiple sclerosis listed in MS society of Kurdistan province, Iran in 1390 that were eligible to our criteria. The sampling method was purposeful and sample size, given the formula $\alpha=0.05$ powered by 0.8 and the extent of expected average effect, was calculated to be 26 in which 4 of them were excluded due to lack of interest. Therefore, 22 samples were selected. Characteristics of samples included patients with MS from 20 to 45 years old, be listed in MS society in 1390, willing to participate in the study, and have no other illness except. The data gathering tool was a demographic questionnaire and marital satisfaction questionnaire.

First introduced by Olson et al. (1985), ENRICH-B marital satisfaction questionnaire includes 47 items in order to evaluate nurturing relationship issues communication and happiness and include sub-measures such as personality issues, marital communication, conflict resolution, financial management, leisure activities, sexual relationships, marriage of children, relatives and friends, and religious orientation (Golman, 1387). Responses are organized in Likert scale (completely agree, agree, neither agree nor disagree, disagree, completely disagree) from 1 to 5. Raw scores between 40 and 60 indicate moderate or partial satisfaction of marital relationship and the higher and lower score indicates dissatisfaction and high satisfaction respectively. The scoring tool can be done in two ways: overall marital satisfaction scores: the scores of individuals scores in all 47 items extracted from questionnaire indicating overall satisfaction score. In order to calculate sub-scales, we first, determined total score for each sub-scale separately and then the total score for each sub-scale is divided by 5. After rounding each score, the results interpreted as following. Grades 1, 2, 3, 4, 5 indicate strong dissatisfaction, dissatisfaction average satisfaction, high satisfaction, and extreme satisfaction, respectively. Regarding the reliability of this questionnaire, Olsen et al. (1998), using alpha coefficient, reported reliability (internal consistency) of this questionnaire equal to be 0.92. In order to determine the validity of the questionnaire, we have used the content validity of the questionnaire so that, the questionnaire was presented to experts and their comments were applied. In addition, Ghorbanalipour et al. (1387) using re-test method, have reported the reliability of the questionnaire equal to r=0.93 (Ghorbanalipour et al. 1387).

In order to conduct the study, after obtaining permission and consent of nursing faculty and presenting it to MS society of Kurdistan province, the sampling was performed as mentioned before and after obtaining patients consents they were asked to fill out marital satisfaction questionnaire and were subjected to 20 two-hours training sessions within 40 days (every other day). Each day, in the morning and afternoon, patients in two 11-person groups of males and females, were subjected to emotional intelligence training through psychodrama.

After grouping patients, in the first stage, a component of emotional intelligence, using psychodrama, was taught to patients by the researcher. Then patients were asked to write their most important problems in marital. Then this script became to a scenario and performed by patients as a theatre occasionally with the presence of their wives. After performing the scenario of problems of one patient, other patients were asked to suggest their solutions. Then the best solution was presented to the performer and he/she advised to make use of the solution in marital life. In the next step, after training sessions, subjects were asked to re-fill marital satisfaction questionnaires. Finally, in order to compare the results before and after training, due to the normality of data, paired t method was used. Ethical considerations in this study were: obtaining written permission from nursing and midwifery faculty of Islamic Azad university of Tehran, medical branch and presenting it to the authorities of Kurdistan MS society, obtaining permission from authorities of the MS society, informed consent form samples to participate in study, granting the right of canceling cooperation to participators, ensuring patients to respect their privacy and not issuing their personal information, and not entering personal attitudes of the researcher to the results.

3. Results

In this study, the effect of teaching emotional intelligence via psychodrama on marital satisfaction of 22 patients with MS who were referred to the MS society of Kurdistan province in 1390 was studied. Results showed that, most of samples were in the 37 to 46 age group having the primary or middle-school levels of education. The majority of subjects (95.5%) were urban residents and housewives (50%). Most of them (63.3%) were hospitalized more than 3 times. In addition, we found that, the 5 to 7 years of disease has the highest percentage (45.4%).

Table 1 shows that, in terms of the characteristics of the subjects, the mean and standard deviation of subjects rose from 3.09 ± 0.9 before training to 3.04 ± 0.7 after training. Paired t test showed no significant differences in the subjects' personality before and after training ($p > 0.05$). This

means that, teaching emotional intelligence through psychodrama had no effect on the subjects' personality dimension of marital satisfaction.

In terms of marital relationship, the mean and standard deviation of subjects rose from 2.95 ± 1.1 before training to 12.95 ± 1.04 after training. Paired t test showed significant differences in the marital relationships before and after training ($p < 0.05$). This means that, teaching emotional intelligence through psychodrama had significant effect on the marital relationships dimension of marital satisfaction.

In terms of conflict resolution, the mean and standard deviation of subjects rose from 3.31 ± 0.9 before training to 8.95 ± 0.7 after training. Paired t test showed significant differences in the conflict resolution before and after training ($p < 0.05$). This means that, teaching emotional intelligence through psychodrama had significant effect on the conflict resolution dimension of marital satisfaction.

In terms of financial management, the mean and standard deviation of subjects rose from 3.13 ± 0.5 before training to 3.81 ± 0.5 after training. Paired t test showed no significant differences in the financial management before and after training ($p > 0.05$). This means that, teaching emotional intelligence through psychodrama had no effect on the financial management dimension of marital satisfaction.

In terms of leisure time activities, the mean and standard deviation of subjects rose from 3.45 ± 0.6 before training to 3.31 ± 0.5 after training. Paired t test showed no significant differences in the leisure time activities before and after training ($p > 0.05$). This means that, teaching emotional intelligence through psychodrama had no effect on the leisure time activities dimension of marital satisfaction.

In terms of sexual relations, the mean and standard deviation of subjects rose from 3.36 ± 0.7 before training to 9.31 ± 0.6 after training. Paired t test showed significant differences in the sexual relations before and after training ($p < 0.05$). This means that, teaching emotional intelligence through psychodrama had significant effect on the sexual relations dimension of marital satisfaction.

In terms of marriage of children, the mean and standard deviation of subjects rose from 2.77 ± 0.8 before training to 2.59 ± 0.5 after training. Paired t test showed no significant differences in the marriage of children before and after training ($p > 0.05$). This means that, teaching emotional intelligence through psychodrama had no significant effect on the marriage of children dimension of marital satisfaction.

In terms of relatives and friends, the mean and standard deviation of subjects rose from 2.50 ± 0.8 before training to 2.31 ± 0.4 after training. Paired t test showed no significant differences in the relatives and friends before and after training ($p > 0.05$). This means that, teaching emotional intelligence through psychodrama had no significant effect on the relatives and friends dimension of marital satisfaction.

In terms of overall marital satisfaction, the mean and standard deviation of subjects rose from 129.54 ± 21.43 before training to 135.81 ± 16.63 after training. Paired t test showed significant differences in the overall marital satisfaction before and after training ($p < 0.05$). This means that, teaching emotional intelligence through psychodrama had significant effect on the overall marital satisfaction.

Table 1: Comparison of the collected scores of marital satisfaction dimensions of subjects before and after training

Score / Dimensions of marital satisfaction	Before the test		After the test		P	t	df
	Mean	Standard deviation	Mean	Standard deviation			
Personality issues	3.09	0.9	3.04	0.7	0.8	0.2	21
Marital relationship	2.95	1.1	12.95	1.04	0.001	7.21	21
Conflict resolution	3.31	0.9	8.95	0.7	0.001	6.35	21
Financial management	3.13	0.5	3.81	0.5	0.1	1.77	21
Leisure time activities	3.45	0.6	3.31	0.5	0.3	1.1	21

Table 1: Comparison of the collected scores of marital satisfaction dimensions of subjects before and after training - continued

Sexual relations	3.36	0.7	9.31	0.6	0.01	3.1	21
Marriage of children	2.77	0.8	2.59	0.5	0.3	0.9	21
Relatives and friends	2.50	0.8	2.31	0.4	0.2	0.1	21
Religious orientation	2.81	0.7	2.54	0.5	0.1	1.2	21
Overall score	129.54	21.43	135.81	16.63	0.001	6.7	21

4. Conclusion

Given the results of this study and other similar studies, teaching emotional intelligence through psychodrama has positive impact on marital satisfaction of patients with multiple sclerosis. About the impact of teaching emotional intelligence through psychodrama on marital satisfaction of patients with MS, there is no similar research. However, the researches on the effect of emotional intelligence training on marital satisfaction of other segments of society, the impact of this approach is clearly evident. Yarmohammadian et al. (1390), investigated the effect of emotional intelligence training and life skills on marital adjustment of young couples and concluded that, teaching emotional intelligence and life skills have significant effect of marital satisfaction and its components ($p < 0.01$) (Yar mohammadian et al., 1390). Ortese and Tor-Anyiin (2008), also investigated the effects of emotional intelligence on marital adjustment of Nigerian couples and came to the conclusion that, emotion management has a significant impact on the marital adjustment (Ortese & Tor-Anyiin, 2008). Joshi et al. (2009), in their study showed that, couples with high emotional intelligence have better marital relations ($p <0.01$). In addition, Soleimaniyan and Mohammadi (1388) in a study examined the relationship between emotional intelligence and marital satisfaction. Their results showed that, emotional intelligence, alone, account for 30 percent of marital changes and there is significant and positive correlation between components of emotional intelligence (attention, clarity, mood repair) and marital satisfaction ($p < 0.01$). This suggests that, if an individual has higher capacity of emotional intelligence growth, he/she could have more adaptive manners in all aspects of life including marital relationship. Perceived emotional intelligence of couples from each other and the proper presentation of emotions to each other is an important factor to improve marital satisfaction. Learning skills such as communicative skills, sympathy, self-esteem, expressional and cognitive skills, decision-making power, problem-solving ability, understanding emotions of self and others, and managing these emotions increase individuals abilities as well as his/her adjustment with others. Teaching EQ via psychodrama has is an effective method to enhance marital satisfaction of healthy individuals and patients specially for those who have various problems and marital issues and have a negative attitude toward referring to a counselor or psychiatrist. According to the results of this study, it is recommended to counseling centers to provide EQ learning sessions along drug treatment in order to improve marital satisfaction of patients. Psychiatrists, psychologists and nurses benefitting their teaching skills can use this method to improve marital satisfaction and quality of life of these patients.

In the field of medical educations in nursing and other disciplines, administrators and health officials can organize training courses, workshops and seminars, and congresses to inform society with these concepts. Moreover, considering that in-service training has always been a part of the health care personnel, therefore, the newest materials and methods should be included in their training programs. Given that, science would not grow without conducting researches, the results of this work could be the foundation of future researches.

Acknowledgements

The authors appreciate the support of MS society, staffs and patients.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.373-379
http://www.europeanjournalofscientificresearch.com

Structured Finger Movements May Enhance Cognitive as Well as Motor Functions of the Brain

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Abstract

This study explored theoretical and experimental basis supporting the values of structured finger movements as a strategy to develop the cognitive functions of brain areas. The stimulation of cerebral areas by gross motor skills influences not only physical skills but also cognitive functions. The functional somatotopy of the primary motor cortex and the primary somesthetic area show that the hand areas comprise the largest portion of cortical tissue. Therefore, finger movements may activate brain areas associated with cognitive functions as well as motor skills. However, previous studies have focused primarily on the motor area of the cerebral cortex. Finger movements can be structured into diverse patterns and the brain activation areas induced by these movements may vary according to the complexity or the manner in which the sensory information is processed. Unlike simple finger movements, performing structured finger movements requiring concurrent visual and tactile information processing can demand the subject's continuous attention to both the current and upcoming stimuli. Therefore, complex structured finger movement tasks could be utilized as a simple exercise intervention to develop the brain areas that perform cognitive functions with the aim of improving cognitive abilities, or delay cognitive decline.

Keywords: Structured Finger Movement, Cognitive Function

1. Introduction

Regular high-intensity physical activities, such as walking or aerobics, could enhance cognitive functions as well as motor skills (Heyn, Abreu, and Ottenbacher, 2004; Hillman, Erickson, and Kramer, 2008), delay the onset of neurodegeneration, and lower the risk of dementia (Rovio et al., 2005). Hence, stimulation of certain cerebral areas by motor activity may positively influence not only physical skills but also cognitive functions. The primary motor cortex and the primary somesthetic area, corresponding to Brodmann's area 4, 5, and 7, are known to receive motor or sensory information from the contralateral side of the body. The somatotopical functional arrangement of these cortical

areas in relation to different body parts is found in the hand and facial areas that account for the largest portion of neuronal tissue (Banich, 2004; Kandel and Schwartz, 2000; Rains, 2002). As with gross motor skills, finger movements may efficiently activate the sensorimotor and cognitive areas of the cerebral cortex.

It has indeed been demonstrated that hand and finger movements induce the activation of widespread brain areas, beyond their representations in the motor and sensory somatic maps (Buccino, Solodkin, and Small, 2006; Buccino et al., 2004; Muthukumaraswamy and Johnson, 2004). Researchers have examined cerebral activation patterns corresponding to finger movement patterns of varying complexity or duration (Cui et al., 2000; Gerloff and Andres, 2002; Sadato, Campbell, Ibanez, Deiber, and Hallett, 1996), during the movement of one or both hands (Deiber, Caldara, Ibanez, and Hauert, 2001; Gerloff and Andres, 2002; Jancke, Shah, and Peters, 2000; Swinnen and Wenderoth, 2004), and simultaneous or sequential finger movements (Gerloff and Andres, 2002; Sadato et al., 1996). Differences in brain activity between experts and novices during hand or finger movement (Jancke et al., 2000; Krings et al., 2000; Nyberg, Eriksson, Larson, and Marklund, 2006; Parsons, Sergent, Hodges, and Fox, 2005), and the neural activation patterns during complex movements while preparing for such movements (Buccino et al., 2004; Cui et al., 2000; Wheaton, Shibasaki, and Hallett, 2005) were also studied. While different movement patterns induced various patterns of neural activation, there is rarely an activity strictly confined to the sensory motor areas. The most commonly activated areas are the supplementary motor area, Broca's area, the premotor cortex, and prefrontal cortex, which are known to be involved in both cognitive functions and movement skills (Bengtsson and Ullen, 2006; Eggermont, Knol, Hol, Swaab, and Scherder, 2009; Filimon, Nelson, Hagler, and Sereno, 2007; Gerloff and Andres, 2002; Nyberg et al., 2006; Parsons et al., 2005; Walsh, Small, Chen, and Solodkin, 2008). Therefore, the above results suggest that finger movements can mutually activate brain areas associated with cognitive functions as well as those responsible for performance of movement.

However, most studies in the area have focused on the activation patterns of the motor area of the cerebral cortex during motor activity of a specific finger. The precise association between complex finger movements and the activation of cognitive brain areas is still not well understood. What method, then, is likely to most efficiently and effectively activate cognitive function areas as well as motor areas through finger movements? Finger movements can be structured into diverse patterns and the brain areas activated by these movements may vary according to the complexity or the manner in which the sensory information is processed. In particular, structured finger movements requiring visual and tactile information processing may be an effective task to induce the stimulation of cognitive areas as well as motor areas of the brain. Such a task calls for a continuous interaction between several brain areas, imposing a considerable cognitive load in the system (Bengtsson, Ehrsson, Forssberg, and Ullen, 2004; Catalan, Honda, Weeks, Cohen, and Hallett, 1998).

In order to review the potential value of structured finger movements aimed at the development or maintenance of brain areas controlling cognitive functions, the purpose of this study is to provide a concise review of theoretical and experimental basis of structured finger movements. This study examined previous studies about the neural activity patterns of the cerebral cortex related to finger movements and reviewed the possibility of improving cognitive function through structured finger movements that require visual and tactile information processing. Our study would increase the understanding of the neurophysiological mechanisms underlying structured finger movements, thereby providing insight into their applicability as a therapeutic intervention to promote and maintain cognitive functions.

2. Finger Movements and Activation Patterns of the Cerebral Cortex

Hand or finger movements represent fine motor skills which may induce the broad activation of brain areas as do gross motor skill (Bengtsson and Ullen, 2006; Eggermont et al., 2009; Filimon et al., 2007). The majority of related studies have focused on the motor area of the cerebral cortex, and the activation

of different brain areas in relation to the type of movement task performed. As mentioned earlier, such studies may be broadly classified into: 1) those investigating activation patterns according to the complexity or duration of the movements, 2) brain areas activated during the movement of one or both hands, 3) differences in brain activity between experts and novices during hand or finger movements, and 4) the activation patterns of brain areas while performing complex movements compared to while preparing for such movements. The following is a consideration of the findings of these different categories.

2.1. Complexity of Hand Movements

To investigate the activation patterns in the cerebrum corresponding with finger movements of varying complexity or duration, Jancke et al. (2000) used functional magnetic resonance imaging (fMRI) to examine hemodynamic responses in right-handed participants during high- and low-speed hand. They found that activation of the contralateral sensorimotor area was significantly stronger during high-speed hand activities than during low-speed activities. Using a 128-channel sensor array, Muthukumaraswamy and Johnson (2004) recorded brain waves of 16 adults while they were grabbing the precision grip of a manipulandum. The researchers demonstrated that the mu rhythm amplitude recorded from the sensorimotor cortex significantly decreased during a precision gripping motion compared to during an empty, false gripping motion. Such results suggest that neurons of the sensorimotor cortex directly engage in hand movement performance. At the same time, the level of activation in this area may increase according to the complexity and intensity of the movement required.

2.2. Movement of One or Both Hands

Previous studies have demonstrated consistent differences in the cerebral activation patterns induced during the movement of one or both hands. Jancke et al. (2000) measured neural activity in the sensorimotor and supplementary motor areas using fMRI. They observed that while activity in the sensorimotor area was similar for both one handed and two handed tasks, in the supplementary motor area, activity was significantly increased during the two handed task. Similarly, Sadato et al. (1996) measured regional cerebral blood flow using positron emission tomography (PET) during one handed or two handed movements. Results showed regional cerebral blood flow significantly increased in the posterior supplementary motor area as well as the right dorsal parietal cortex and the right premotor cortex while participants were performing asymmetrical two handed movements compared to either symmetrical movements or one handed movements. These findings suggest that two handed movements increase the task load and consequently increase activation of the relevant brain area to a greater degree relative to one handed movements in accordance with the complexity of the motor control system.

2.3. Cerebral Activation in Experts and Novices

Many studies have addressed differences in brain activity patterns between experts and novices while performing hand movements. For example, Krings et al. (2000) used fMRI to examine cerebral blood oxygenation levels in piano players and in control subjects during performance of a complex finger task. They found neural activities in the primary motor cortex, the supplementary motor area, the premotor area, and the superior parietal lobule were significantly increased in both groups during the task. However, these areas showed a greater decrease in the number of active voxels in the expert group compared with their control counterparts. In accordance with this, Nyberg et al. (2006) measured brain activity patterns at 1 week intervals using fMRI while subjects performed a finger-tapping task with their left hand. Activations in some brain areas including the right motor cortex and the left cerebellum showed more limited patterns during later recording sessions (i.e., after training compared to before training). Such results suggest that long-term practice reduces the extent of neuronal activity

required to accomplish a given task and that the brain learns to process practiced information more efficiently, thereby demanding less neural resources over time.

2.4. Cerebral Activation during Movement and Preparation Periods

Sixty-four-channel brain recordings were made from 16 volunteers during the performance of sequential simple and complex tasks using both hands. The initial signals were detected in the primary motor cortex and the supplementary motor area, and the amplitude, duration, onset time, and intensity of the signals increased as the complexity of the required movements added (Cui et al., 2000). In a study of signal initiation in the brain when hand movements were started, Wheaton et al. (2005) measured cortical electric potentials using EEG during communicative gesture movements made with the right hand. Approximately 3 seconds prior to the start of the movement, a potential was generated in the left parietal lobe and sensorimotor cortex and then transmitted to the same area in the right hemisphere.

Previous studies analyzing neurophysiological responses in the brain have demonstrated that finger movements are accompanied by the activation of a number of different brain areas. The supplementary motor area, Broca's area, premotor cortex, and prefrontal lobe cortex are all known to be engaged in the performance of cognitive functions as well as movement skills (Bengtsson and Ullen, 2006; Eggermont et al., 2009; Filimon et al., 2007; Gerloff and Andres, 2002; Nyberg et al., 2006; Parsons et al., 2005; Sadato et al., 1996; Swinnen and Wenderoth, 2004; Walsh et al., 2008). Evidences from the above studies suggest that there is a considerable potential for systematic finger movements to strengthen not only the relevant sensorimotor neural network, but possibly the cognitive networks that become active during such movements.

3. Improvement of Cognitive Functions through Structured Finger Movements using Visual and Tactile Information

Previous studies have attempted to identify the activation patterns in motor areas related to the hands using a diverse array of movement tasks. It has been found that the cognitive as well as motor areas of the brain are concurrently activated during hand movements since brain areas are interconnected and display coactivation during performance of motor tasks (Catalan et al., 1998; Hari et al., 1998; Pfurtscheller, Neuper, Pichler-Zaluiek, Edlinger, and Lopes da Silva, 2000; Salenius, Portin, Kujola, Salmelin, and Hari, 1997). The primary motor cortex and the primary somesthetic area exhibit an obvious correspondence connection, with the hand area accounting for a relatively large portion of such connection (Banich, 2004; Rains, 2002). In particular, given the interrelation between the primary motor cortex and secondary motor areas, and their interconnectivity with the cerebrum, it is expected that finger movement in particular has the capacity to activate widespread brain areas including the cognitive networks as well as motor area of the cerebrum (Jancke et al., 2000). Based on these studies, structured finger movements requiring the integration of sensory information and motor tasks may activate the cognitive areas as well as the sensorimotor areas of the brain in a synergistic manner.

While preparing for the performance of complex finger movements, high-level motor areas such as the primary motor cortex are activated (Sadato et al., 1996). The increasing complexity of the assigned tasks may increase the task load on the motor and cognitive brain areas (Gerloff and Andres, 2002; Jancke et al., 2000; Matsuo et al., 2003; Sadato et al., 1996; Swinnen and Wenderoth, 2004). Koechlin, Danek, Burnod, and Grafman (2002) noted that cognitive and sequential motor movements induce activation of the same brain areas. For instance, cognitive tasks such as reading or math activate the prefrontal and parietal lobes similar to performing sequential movement tasks. Hillman et al. (2008) reported that increased physical activity may improve learning effects, and that both of the above brain areas were involved in the effect. Kayako et al. (2001) reported the simultaneous activation of the frontal, parietal, and occipital lobes in participants performing a Kanji puzzle using their right index finger. Unlike simple finger movements, structured finger movements requiring concurrent visual and tactile information processing demand the subject's continuous attention to both the current and next

stimuli in order to successfully perform the required motor task, thus requiring the recruitment of areas directly related to cognitive processing.

Thus structured finger movement requiring visual and tactile information processing may be an effective protocol for developing cognitive functions. It seems obvious that the structured finger movements can become an efficient modality for improving cognitive functions in children and the elderly. In addition, preventing sudden cognitive degeneration in the elderly is another plausible application of the structured finger movements with visual and tactile information processing. For instance, regular training of complex finger movements may challenge the cognitive areas of the brain in the elderly resulting in an improvement in the cognitive functioning. However, more research are required to better understand the effect of structured finger movement on cognitive functions in children and the elderly.

4. Conclusions

Performing a complex combination of finger movements requiring active processing of sensory information may efficiently activate cognitive as well as motor areas of the cerebral cortex. Structured finger movements requiring a combination of visual and tactile information processing are related to high-level mental processing that demands the integration of sensory information and motor tasks. Such movements may induce activation of the frontal area as well as the sensorimotor area directly related to cognitive and motor functioning. Thus various combination of structured finger movement can be used in an exercise protocol as a simple exercise intervention to develop and/or maintain cognitive functions of the brain with the aim of improving cognitive abilities, or delaying cognitive decline. This approach seems to represent a simple, low-cost, and low-technology strategy that can be easily implemented in a training or rehabilitative context to promote the development of cognitive functions in children, as well as to delay neurological degeneration in the elderly.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.380-393
http://www.europeanjournalofscientificresearch.com

Security Improvement of an Image Encryption Based on mPixel-Chaotic-Shuffle and Pixel-Chaotic-Diffusion

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Abstract

In this paper, we propose to improve the security performance of a recently proposed color image encryption algorithm which is based on multi-chaotic systems. The existing cryptosystem employed a pixel-chaotic-shuffle mechanism to encrypt images, in which the generation of shuffling sequences are independent to the plain-image/cipher-image. As a result, it fails to the chosen-plaintext and known-plaintext attacks. Moreover, the statistical features of the cryptosystem are not up to the standard. Therefore, the security improvements are framed to make the above attacks infeasible and enhance the statistical features as well. It is achieved by modifying the pixel-chaotic-shuffle mechanism and adding a new pixel-chaotic-diffusion mechanism to it. The keys for diffusion of pixels are extracted from the same chaotic sequences generated in the previous stage. The simulation analyses and studies are performed to demonstrate that the updated version of cryptosystem has better statistical features and resistant to the chosen-plaintext and known-plaintext attacks than the existing algorithm.

Keywords: Multiple Chaotic Systems, Image Cryptosystem, Attacks, Modified Pixel-Chaotic-Shuffle, Pixel-Chaotic-Diffusion

1. Introduction

In today's world of technological advancements in web, multimedia and wireless networks, the multimedia data such as digital images, audio, video becomes a crucial means of communication. It leads to easiness in unauthorized access, illegal usage, malicious alteration and disruption of sensitive multimedia data for intruders and attackers. So, there is an increasing demand for building robust and efficient security methods for privacy protection of digital multimedia data while transmitting them

over the Internet and wireless networks. A possible conventional solution is to use encryption techniques to secure sensitive data. Encryption is the mathematical transformation of plaintext data into unintelligible form to provide data confidentiality, integrity, authentication and non-repudiation. It provides an end-to-end secure communication. The core idea behind encryption is to protect plaintext data that can only be apprehensible on decryption with correct secret key by a legal recipient. A strong encryption technique should have high statistical features, resistant to cryptographic attacks and fulfill the classical Shannon requirement of confusion and diffusion [1]. Confusion makes the relationship between the key and ciphertext as complex as possible, where as diffusion reshuffle bits of plaintext so that any redundancy in the plaintext is spread out over the ciphertext [2]. There are a number of traditional encryption techniques like DES, AES, IDEA, RSA, etc [2-4]. These techniques are effective in providing good confusion and diffusion for encrypting text data, but these number-theory based encryption techniques are not well-suited for multimedia data. The multimedia data is usually very large-sized and bulky; its adjacent pixels/frames have high correlation, has spatial and temporal redundancies. Encrypting such data using traditional techniques incurs high computing power, large computation time and high expenses for real-time multimedia applications like video conferencing, image-surveillance, image-based military and satellite communication etc. Hence, it demands better solutions to resolve the security problems of multimedia data effectively.

The chaotic signals have several features that resembles to some cryptographic properties like (1) The ergodicity property of chaotic signals resembles the confusion property in cryptography, (2) High sensitivity of chaotic signals to their initial conditions/system-parameters resembles the diffusion property of cryptography and (3) Noise-like behavior of chaotic sequences resembles the key sequences used in cryptography. The highly sensitive response of chaotic systems to initial conditions makes their trajectory unpredictable and highly random. Moreover, the generation of discrete chaotic signals using chaotic systems often requires low cost. Consequently, the chaos-based cryptography has gained attention of researchers and academician to develop chaos-based methods for securing multimedia data. The first chaos based image encryption algorithm was proposed by R. Matthews [5]. Chaos-based cryptosystems provide strong encryption effect, better statistical features and high security. As a result, they are extensively exploited for encrypting multimedia images and videos [6-21]. However, some of them suffer from serious security flaws and are incompetent to withstand even the classical and other types of cryptographic attacks, as exposed by many cryptanalysts [22-28].

Most of the chaos-based image encryption algorithms are based on confusion and diffusion techniques. Confusion technique shuffles the positions of pixels in plain-image to get visually disordered and unrecognizable image. Diffusion technique alters the statistical characteristics of image by modifying the gray-values of pixels. Deployment of confusion and diffusion stages together provides higher encryption effect, robustness and security. Scharinger [6] suggested a chaotic kolmogorov-flow based image encryption algorithm. The image is permuted through a key-controlled system and gray-value substitution is based on a shift-registered pseudo-random number generator. Fridrich [7] suggested a cryptosystem in which the permutation of image pixels is done using 2D chaotic map. In the diffusion stage, the pixel values are changed depending on the accumulated effect of all previous pixels. Chen *et al.* [8] extended a 2D Cat map to 3D map to de-correlate relations among image pixels. The confusion is done by permuting the image pixels through extended 3D Cat map. Logistic map and 3D Chen's system are employed to diffuse the image. Mao *et al.* [9] extended the concept of Chen *et al.* [8] by employing a 3D Baker's map instead of 3D Cat map at the confusion stage. Fu *et al.* [10] employed preprocessed sequences generated by 3D Lorenz system to perform the confusion and diffusion. The encryption speed is improved as the position permutation and gray-value substitution of pixel is done in one iteration operation. Dongming *et al.* [11] constructed an ergodic matrix using Logistic map after executing an optimized preprocessing to permute the pixels of plain-image and a discretized Chen system is employed at diffusion stage to improve the encryption performance. Liu *et al.* [12] used an improved 3D Cat map for pixels shuffling and gray-value

substitution, where the control parameters of Cat map are generated through 2D Henon's map and 2D coupled Logistic map is employed to generate parameters of substitution. Patidar *et al.* [13] presented a loss-less symmetric color image encryption algorithm based on chaotic 2D standard map and 1D Logistic map. In their algorithm, there are four rounds: two rounds for substitution/confusion and two rounds for diffusion. The first round of substitution/confusion is achieved with the help of intermediate XORing keys calculated from secret key. Then rounds for horizontal and vertical diffusions are completed by mixing the properties of horizontally and vertically adjacent pixels, respectively. In the last round, substitution/confusion is accomplished by generating an intermediate chaotic key stream image using chaotic standard and logistic maps. Tang *et al.* [14] suggested a new image encryption scheme using coupled map lattices (CML) with time-varying delays. A discretized tent map is employed to permute the positions of image pixels and a delayed CML is used to confuse the relationship between the plain-image and the cipher-image. The features of fourth-order hyper-chaotic system are improved and explored by Zhu [15] for designing an image encryption method. In [16], a new image encryption scheme based on coupling of chaotic function and XOR operator is provided. The scheme has the features of high security, sensitivity and randomness. Hongjun *et al.* [17] designed a stream-cipher algorithm based on one-time keys and robust chaotic maps in order to get high security and improved dynamical degradation, where the initial conditions are generated by the MD5 of mouse positions. This makes the algorithm robust against noise and makes known attacks infeasible. In [18], the authors proposed an image encryption algorithm by exploring the features of DNA computing and chaotic logistic function.

In 2009, Huang *et al.* [20] proposed pixel-chaotic-shuffle based color image encryption algorithm. The algorithm uses four three-dimensional chaotic systems for pixels bits shuffling. Solak *et al.* [22] breaks their scheme successfully by cracking the shuffling sequences that are equivalent keys of cryptosystem. This paper presents security improvements to make existing cryptosystem robust against Solak *et al.* attacks and to enhance its statistical features.

2. Proposed Security Improvements

The Huang *et al.* [20] proposed a pixel-chaotic-shuffle mechanism which utilizes four 3D chaotic systems namely the Henon map, the Lorenz map, the Chua map and the Rossler map for encrypting color images. The four 3D chaotic systems used in the design are described by Eqns (1)-(4) in Section 2.1 of Ref. [20]. We refer them as Eqns (1)-(4) in the later part of this paper. These chaotic systems are iterated and processed to generate the shuffling sequences. In pixel-chaotic-shuffle mechanism, the whole idea of encryption of RBG images involves two phases. In the first phase, the bits of binarized-image component are permuted vertically by performing column-wise indexing and shuffling. In the second phase, the 8-bits of each pixels of image component are rearranged horizontally within themselves through row-wise indexing and shuffling. One major shortcoming of Huang *et al.* algorithm is that the generation of shuffling sequences is independent to the pending plain-image or the cipher-image. As a consequence, it generates same sequences for encrypting different plain-images. Another reason which makes the work of attacker easier is that each color component of plain-image is processed separately and independently. These shortcomings facilitate the cryptanalysts Solak *et al.* [22] to break their algorithm.

We propose security improvements in Huang *et al.* algorithm with similar basic description, parameters and functions used. The improvements are framed to rule out the aforesaid shortcomings of the existing method. A modified pixel-chaotic-shuffle mechanism is presented to (1) create a dependency of twelve shuffling sequences to the plain-image to be encrypted and (2) process three components of color image collectively and dependently. Moreover, the modified pixel-chaotic-shuffle mechanism is appended by proposed pixel-chaotic-diffusion mechanism to enhance the statistical features of updated version. As a result, the improvements make the cryptanalysis, executed in [22], infeasible and also improves the statistical features of cryptosystem.

The plaintext color image P of size $m \times n \times 3$, is first vectorized using raster-scan method (in $R \rightarrow G \rightarrow B$ order) to obtain an array of size $N \times 3$, where $N = mn$. The pixel's intensity values are decomposed into its binary equivalents of 8-bit format to form a binary image matrix ξ of size $N \times 24$. To make the shuffling sequences dependent on plain-image, the total number of 1s in binarized color image ξ is calculated, let it be Δ. The four parameters N_H, N_L, N_C and N_R are evaluated based on the value of Δ. The four chaotic systems with specified key parameters are iterated for N_H, N_L, N_C and N_R times and resulted chaotic values are discarded. It is done to achieve two purposes: (1) to establish a relation between the plain-image and the chaotic sequences or eventually the shuffling sequences and (2) to remove the transient effect of the chaotic systems used. The future trajectories of the four systems are solely controlled by the parameter Δ, which is specific to the pending plain-image. Thus, it extracts information from the plain-image and utilizes it to iterate the chaotic systems. Consequently, an entirely different set of sequences are generated when encrypting a slightly different plain-image. It plays a key role in defeating the potential chosen-plaintext attack and known-plaintext attack. The 24-bits of each row of binary image matrix ξ is manually arranged in a manner shown in Figure 1, to bring the initial confusion among RGB pixels, let Ψ_{rgb} be the matrix obtained. This way establishing the dependency of components on each other, this in turn increases the computation of cryptanalysis. Thus 8-bit pixel of each R, G, B component, that was shuffled individually in [20], is replaced by 24-bit pattern for each RGB pixel in the updated version. The procedure is then followed by column-wise indexing and shuffling, row-wise indexing and shuffling and pixel-chaotic-diffusion.

The following twelve chaotic sequences are obtained on applying next mn iterations to each chaotic systems, $X_i(k)$, $Y_i(k)$ and $Z_i(k)$ where $i = 1, 2, 3, 4$.

$$\begin{aligned} X_i &= \{x_i(1), x_i(2), \cdots\cdots, x_i(mn)\} \\ Y_i &= \{y_i(1), y_i(2), \cdots\cdots, y_i(mn)\} \\ Z_i &= \{z_i(1), z_i(2), \cdots\cdots, z_i(mn)\} \end{aligned}$$

To improve their stochasticity and randomness, these sequences are preprocessed using following formulation [10], where $k = 1, 2, \ldots\ldots, mn$.

$$\begin{aligned} \hat{X}_i(k) &= \{X_i(k) \times 10^6 - floor(X_i(k) \times 10^6)\} \\ \hat{Y}_i(k) &= \{Y_i(k) \times 10^6 - floor(Y_i(k) \times 10^6)\} \\ \hat{Z}_i(k) &= \{Z_i(k) \times 10^6 - floor(Z_i(k) \times 10^6)\} \end{aligned} \tag{5}$$

Now, each member of the sequences lies in the interval of (0, 1). To quantify the randomness of above preprocessed sequences, they are transformed to binary sequences $bSeqX$, $bSeqY$ and $bSeqZ$ using a threshold of $\theta = 0.5$ by Eqn. (6)-(8). The standard NIST statistical test suite [29] is applied to evaluate the randomness performance of these sequences.

$$bSeqX_i(k) = \begin{cases} 0 & for \quad \hat{X}_i(k) < \theta \\ 1 & for \quad \hat{X}_i(k) \geq \theta \end{cases} \tag{6}$$

$$bSeqY_i(k) = \begin{cases} 0 & for \quad \hat{Y}_i(k) < \theta \\ 1 & for \quad \hat{Y}_i(k) \geq \theta \end{cases} \tag{7}$$

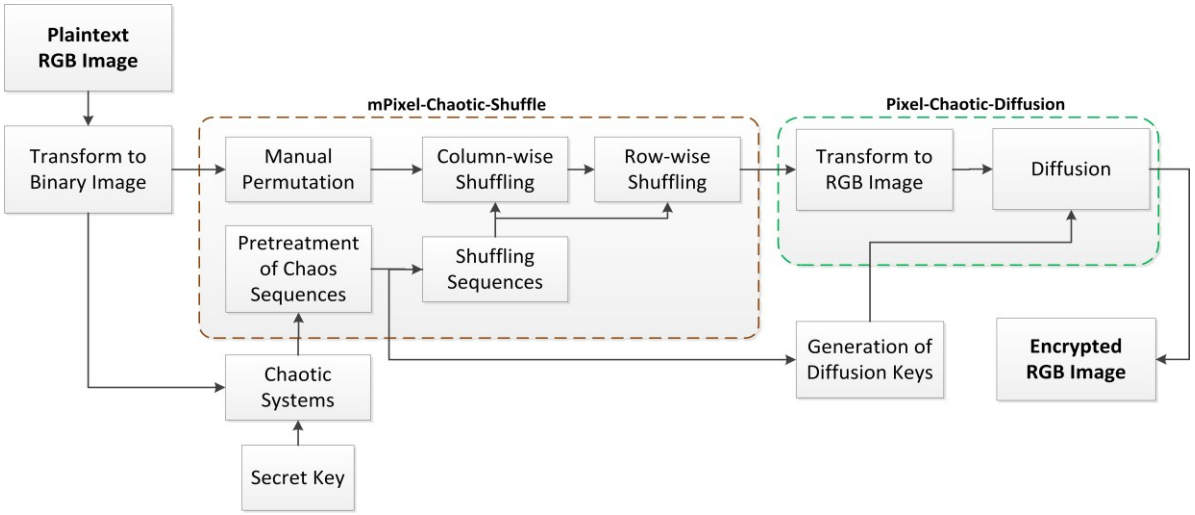
$$bSeqZ_i(k) = \begin{cases} 0 & for \quad \hat{Z}_i(k) < \theta \\ 1 & for \quad \hat{Z}_i(k) \geq \theta \end{cases} \tag{8}$$

The results of various statistical tests are listed in the Table 1. It is clear from the Table that all twelve sequences successfully passed the randomness tests as the associated p_values are higher than 0.01. These stochastically better preprocessed sequences are utilized to produce shuffling and encryption key sequences in proposed improved version.

Table 1: Randomness test results of twelve sequences by NIST statistical test suite

Statistical Test	$bSeqX_1$ (p_value)	$bSeqX_2$ (p_value)	$bSeqX_3$ (p_value)	$bSeqX_4$ (p_value)	$bSeqY_1$ (p_value)	$bSeqY_2$ (p_value)	$bSeqY_3$ (p_value)	$bSeqY_4$ (p_value)	$bSeqZ_1$ (p_value)	$bSeqZ_2$ (p_value)	$bSeqZ_3$ (p_value)	$bSeqZ_4$ (p_value)	Results
Frequency Test	0.838384	0.096299	0.350555	0.593732	0.838384	0.881516	0.962459	0.525157	0.844519	0.366986	0.832259	0.777631	*All Success*
Block Frequency Test	0.649814	0.334810	0.669590	0.918253	0.850038	0.354371	0.654242	0.497521	0.795345	0.803055	0.035018	0.401879	*All Success*
Cusum-Forward Test	0.694591	0.017580	0.208817	0.768087	0.698272	0.538884	0.611208	0.572753	0.701954	0.471638	0.979937	0.720381	*All Success*
Cusum-Reverse Test	0.877724	0.124895	0.447502	0.804052	0.880807	0.421359	0.654330	0.735115	0.877724	0.679896	0.912647	0.948732	*All Success*
Runs Test	0.124118	0.486930	0.277482	0.137872	0.124118	0.319077	0.712359	0.998736	0.126052	0.194433	0.566756	0.017443	*All Success*
Longest Runs Test	0.111325	0.103773	0.121785	0.080958	0.111325	0.580547	0.240356	0.676767	0.111325	0.188293	0.582790	0.507158	*All Success*
Rank Test	0.211605	0.621915	0.674257	0.014727	0.674257	0.918215	0.047407	0.669556	0.206921	0.776819	0.038096	0.472473	*All Success*
FFT Test	0.702631	0.296714	0.959403	1.000000	0.702631	0.779504	0.898737	0.721601	0.838657	0.460460	0.683845	0.524591	*All Success*
Linear Complexity Test	0.211212	0.846274	0.088353	0.191590	0.645386	0.912424	0.467533	0.165069	0.063691	0.846274	0.030934	0.543717	*All Success*
Serial Test	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	*All Success*

Figure 1: Schematic block diagram of the proposed improved algorithm.



The block diagram of the proposed algorithm is depicted in Figure 1 and the algorithmic steps are as follows:

Step 1. Read the color image P_{RGB} and prepare it to get binary image matrix ξ_{rgb} of size $mn \times 24$.

[modified Pixel-Chaotic-Shuffle Stage]

Step 2. Determine the number of 1's in the matrix ξ_{rgb}, let it be Δ and evaluate the parameters N_H, N_L, N_C and N_R from Δ as:

$N_H = (\Delta) mod (997) + 829$

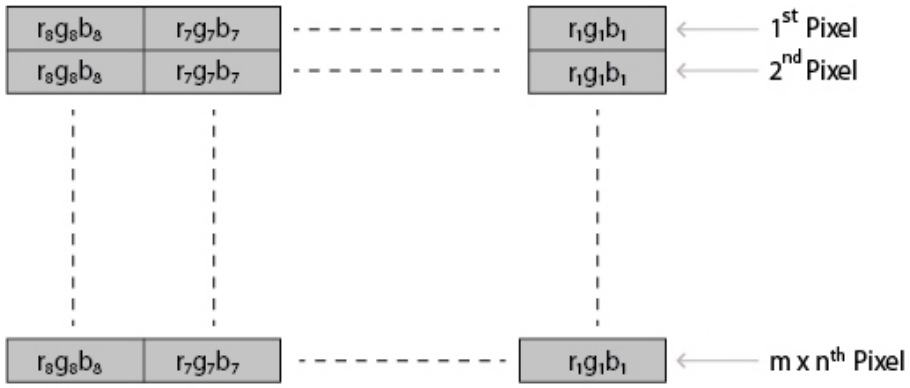
$N_L = (\Delta) mod (937) + 529$

$N_C = (\Delta) mod (1097) + 719$

$N_R = (\Delta) mod (397) + 1123$

Step 3. Manually arrange the bits of image matrix ξ_{rgb}, as shown in Figure 2, to form matrix $\Psi_{rgb(mn\times 24)}$.

Figure 2: Manual arrangement of 24-bits of image matrix.



Step 4. Select the initial conditions and parameters for the four chaotic systems.

Step 5. Iterate the four chaotic systems of Eqns (1)-(4) for N_H, N_L, N_C and N_R times and discard the chaotic values.

Step 6. Again iterate the chaotic systems of Eqns (1)-(4) for next mn times to capture the sequences $X_{1(\mu,1)}$ *to* $X_{4(\mu,1)}$, $Y_{1(\mu,1)}$ *to* $Y_{4(\mu,1)}$ and $Z_{1(\mu,1)}$ *to* $Z_{4(\mu,1)}$, where $\mu = 1, 2, 3, \ldots, mn$.

Step 7. Preprocess the chaotic sequences through Eqn. (5).

Step 8. Extract the indexing sequences $F_{X1} \sim F_{X4}$, $F_{Y1} \sim F_{Y4}$ and $F_{Z1} \sim F_{Z4}$ from preprocessed chaotic sequences $\hat{X}_1 \sim \hat{X}_4$, $\hat{Y}_1 \sim \hat{Y}_4$ and $\hat{Z}_1 \sim \hat{Z}_4$ as:

$$F_{X1} = sort\,(\hat{X}_{1(\mu,1)})\ F_{X2} = sort\,(\hat{X}_{2(\mu,1)})\ F_{X3} = sort\,(\hat{X}_{3(\mu,1)})\ F_{X4} = sort\,(\hat{X}_{4(\mu,1)})$$

$$F_{Y1} = sort\,(\hat{Y}_{1(\mu,1)})\ F_{Y2} = sort\,(\hat{Y}_{2(\mu,1)})\ F_{Y3} = sort\,(\hat{Y}_{3(\mu,1)})\ F_{Y4} = sort\,(\hat{Y}_{4(\mu,1)})$$

$$F_{Z1} = sort\,(\hat{Z}_{1(\mu,1)})\ F_{Z2} = sort\,(\hat{Z}_{2(\mu,1)})\ F_{Z3} = sort\,(\hat{Z}_{3(\mu,1)})\ F_{Z4} = sort\,(\hat{Z}_{4(\mu,1)})$$

where *sort(.)* is a sequencing index function defined in [20].

Step 9. Apply shuffle function $sq(\cdot)$ on Ψ_{rgb} for column-wise shuffling as shown in Figure 3 using shuffling indices $F_{X1} \sim F_{X4}$, $F_{Y1} \sim F_{Y4}$ and $F_{Z1} \sim F_{Z4}$. The function $sq(\cdot)$ shuffles the bits of matrix Ψ_{rgb} using above indexing sequences. Thus, we get a partially encrypted column shuffled binary image matrix as:

$$\psi_{ergb\mu} = [\psi_{ergb\mu 1}\psi_{ergb\mu 2}\cdots\cdots\cdots\psi_{ergb\mu 24}]$$

where,

$$\psi ergb_{\mu i} = \begin{Bmatrix} sq(\psi rgb_{\mu i}, Fx_1), i = 1,2 \\ sq(\psi rgb_{\mu i}, Fx_2), i = 3,4 \\ sq(\psi rgb_{\mu i}, Fx_3), i = 5,6 \\ sq(\psi rgb_{\mu i}, Fx_4), i = 7,8 \\ sq(\psi rgb_{\mu i}, Fy_1), i = 9,10 \\ sq(\psi rgb_{\mu i}, Fy_2), i = 11,12 \\ sq(\psi rgb_{\mu i}, Fy_3), i = 13,14 \\ sq(\psi rgb_{\mu i}, Fy_4), i = 15,16 \\ sq(\psi rgb_{\mu i}, Fz_1), i = 17,18 \\ sq(\psi rgb_{\mu i}, Fz_2), i = 19,20 \\ sq(\psi rgb_{\mu i}, Fz_3), i = 21,22 \\ sq(\psi rgb_{\mu i}, Fz_4), i = 23,24 \end{Bmatrix}$$

and $\Psi_{rgb\mu i}$ is the ith bit of the μth row of matrix Ψ_{rgb}.

Step 10. Perform row-wise shuffling of bits within each row of matrix Ψ_{ergb} obtained in above step in pairs of 2 using indices obtained in Step 7. Let the matrix obtained be Ψ_{srgb} of size $mn \times 24$.

Step 11. Prepare the shuffled binary image matrix Ψ_{srgb} to get RGB shuffled image S_{RGB} of size $m \times n \times 3$.

[Pixel-Chaotic-Diffusion Stage]

Step 12. Decompose the shuffled image S_{RGB} into three gray-scale images of S_R (red), S_G (green) and S_B (blue), arrange their pixels in raster-scan order to get three 1D sequences as:

$$S_R = \{S_R(1), S_R(2), \cdots\cdots, S_R(mn)\}$$
$$S_G = \{S_G(1), S_G(2), \cdots\cdots, S_G(mn)\}$$
$$S_B = \{S_B(1), S_B(2), \cdots\cdots, S_B(mn)\}$$

Step 13. Extract the key sequences for diffusion using the preprocessed chaotic sequences $\hat{X}_1 \sim \hat{X}_4$, $\hat{Y}_1 \sim \hat{Y}_4$ and $\hat{Z}_1 \sim \hat{Z}_4$ obtained earlier (k = 1 ~ mn).

$$keyX_i(k) = \{floor(\hat{X}_i(k) \times 10^{14})\} \bmod (256)$$
$$keyY_i(k) = \{floor(\hat{Y}_i(k) \times 10^{14})\} \bmod (256)$$
$$keyZ_i(k) = \{floor(\hat{Z}_i(k) \times 10^{14})\} \bmod (256)$$

Step 14. Choose $C_R(0)$, $C_G(0)$ and $C_B(0)$.

Step 15. Iterate the following for $j = 1 \sim mn$.

$t_1 = (C_B(j\text{-}1)) mod (12)$; $t_2 = (C_R(j\text{-}1)) mod (12)$; $t_3 = (C_G(j\text{-}1)) mod (12)$;

$C_R(j) = S_R(j) \oplus \{C_R(j\text{-}1) + Key(j, t_1)\} mod (256)$

$C_G(j) = S_G(j) \oplus \{C_G(j\text{-}1) + Key(j, t_2)\} mod (256)$

$C_B(j) = S_B(j) \oplus \{C_B(j\text{-}1) + Key(j, t_3)\} mod (256)$

the definition of *Key* is provided in Table 2.

Step 16. Combine the encrypted gray-scale images C_R, C_G and C_B to encrypted color image C_{RGB} of size $m \times n \times 3$.

Figure 3: Column-wise shuffling of bits in vertical direction in matrix Ψ_{rgb}.

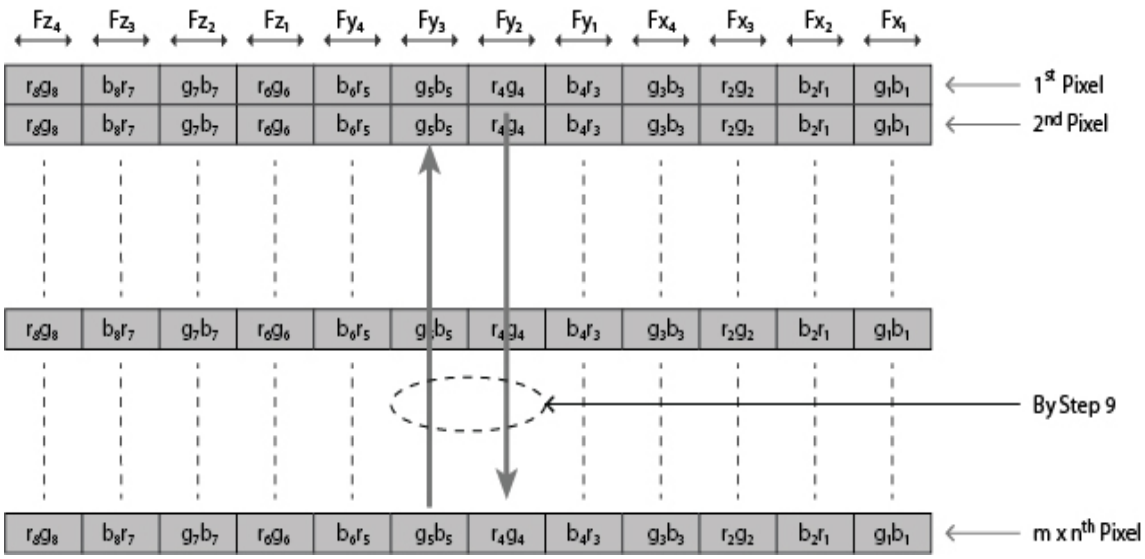


Table 2: Actual diffusion keys

Key(j, t)	$keyX_1(j)$	$keyY_1(j)$	$keyZ_1(j)$	$keyX_2(j)$	$keyY_2(j)$	$keyZ_2(j)$
t	0	1	2	3	4	5
Key(j, t)	$keyX_3(j)$	$keyY_3(j)$	$keyZ_3(j)$	$keyX_4(j)$	$keyY_4(j)$	$keyZ_4(j)$
t	6	7	8	9	10	11

3. Experimental Analyses and Results

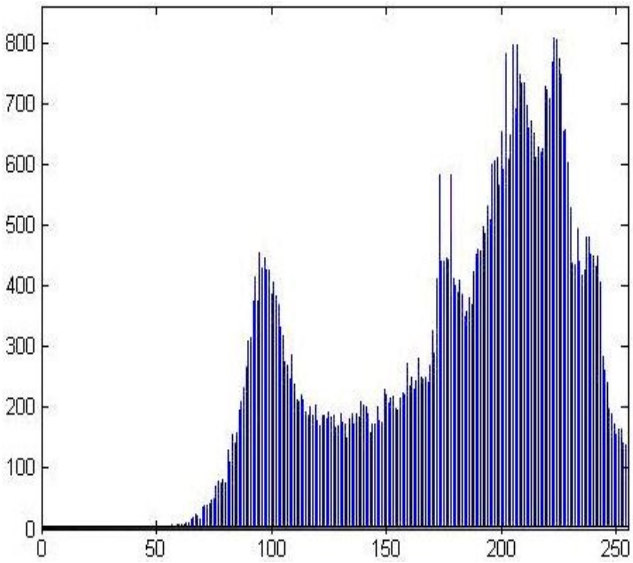
Same standard color image *Lena* of size 256×256×3 is taken as test image to justify the improved security and robustness performance of proposed version. The two algorithms under consideration are implemented in MATLAB. The following simulation analyses are carried out to evaluate the security performance of both the algorithms.

3.1. Histogram Analysis

Image encryption performance evaluation via histograms is an effective criterion. Image histogram illustrates how pixels in an image are distributed. The histograms of *R, G, B* components of original *Lena* image and its encrypted image using existing algorithm are shown in Figure 4. Figure 5 depicts the histograms of *R, G, B* components of encrypted image obtained with proposed version. The histograms obtained for the case of existing technique has more number of peaks as compared to the histograms in proposed technique. The image with flat histogram level is analogous to a noise-image. The histograms shown in Figure 5 resemble that of a noisy image. It can be observed that more flat and fairly uniform histograms are obtained with proposed updated algorithm. The encrypted image shown in Figure 5 has cryptographically better pixels distribution than the pixels of encrypted image obtained with the existing Huang *et al.* algorithm.

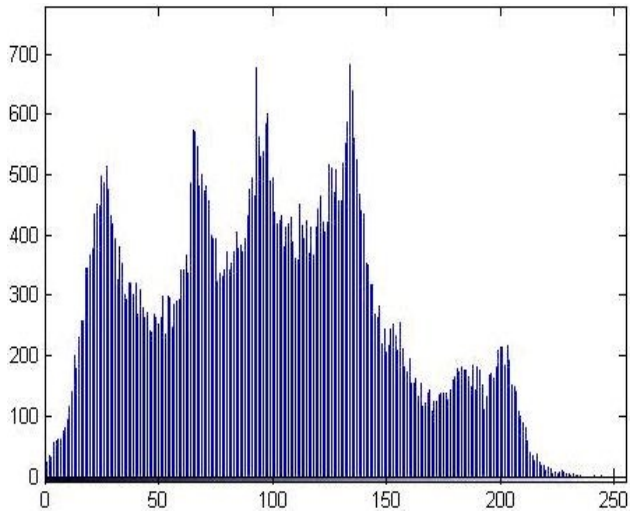
Figure 4: Plain-image of '*Lena*' and histograms of its *R, G*, *B* components.

(a) Test image *'Lena'*

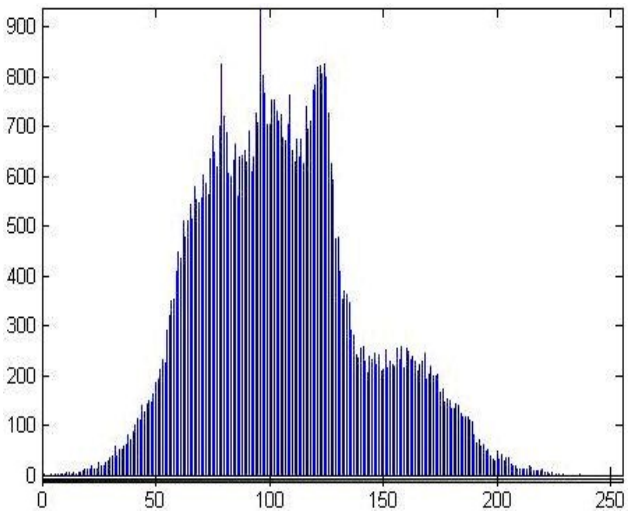


(b) *R* component

Figure 4: Plain-image of '*Lena*' and histograms of its *R, G*, *B* components. - continued



(c) *G* component



(d) *B* component

3.2. Mean Gray Value Analysis

In the proposed version, the statistical properties of color plain-images are improved in such a manner that encrypted images have good balance property. To quantify the balance property of images, the mean gray values of plain-image and encrypted images are evaluated and listed in Table 3. As can be seen from scores that no matter how gray-values of plain-image are distributed, the mean gray-values of encrypted images come out closer to 127.5 (ideal value for a gray-scale perfect noise image) as compared to the existing cryptosystem. This shows that the improved version doesn't provide any information regarding the distribution of gray values to the attacker in the encrypted images.

Table 3: Mean gray-values of images

	Red	**Green**	**Blue**
Original	180.22	99.05	105.41
Huang *et al.* [20]	147.78	109.03	127.51
Xiao *et al.* [21]	NA	NA	NA
Proposed version	127.51	127.97	127.93

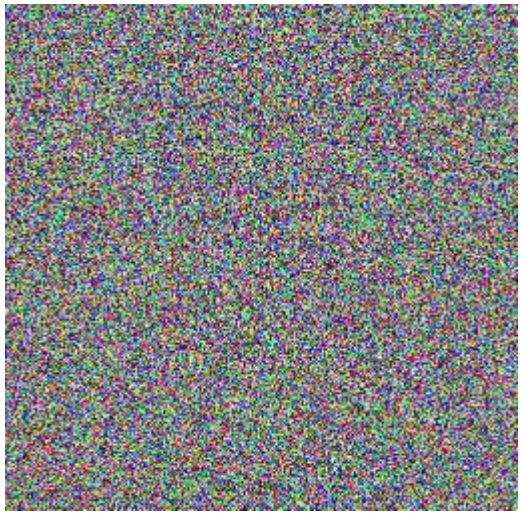
3.3. Chi-Square Analysis

The security performance of an encryption method is also quantified through chi-square test [30]. It is a statistical test used to examine the variations of data from the expected value. The chi-square parameter $\chi 2$ is defined as:

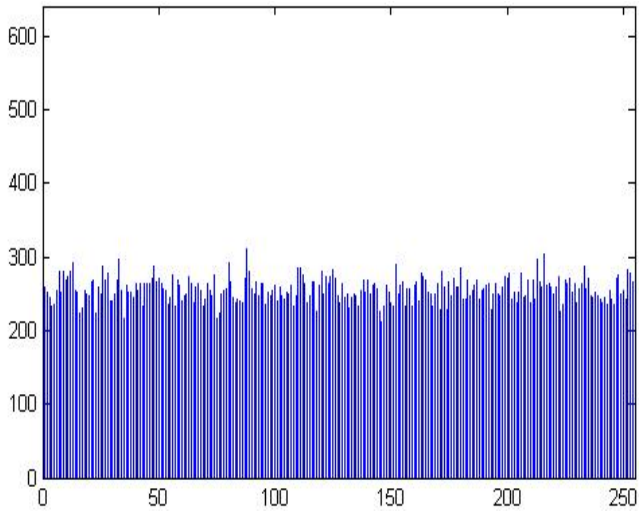
$$\chi^2 = \sum_{i=1}^{256} \frac{(P_i - C_i)^2}{C_i} \tag{9}$$

Where i is number of gray values, P_i and C_i are observed and expected occurrence of each gray value (0 to 255), respectively. The less the value of chi-square χ^2 better will be the encryption performance of the scheme. The values of chi-square for images under study are listed in Table 4. It can be observed that chi-square values for proposed method are extremely low as compared to the values obtained for the original image and Huang *et al.* encrypted image. The extremely low values of chi-square validate that the proposed method offers fairly high encryption effect.

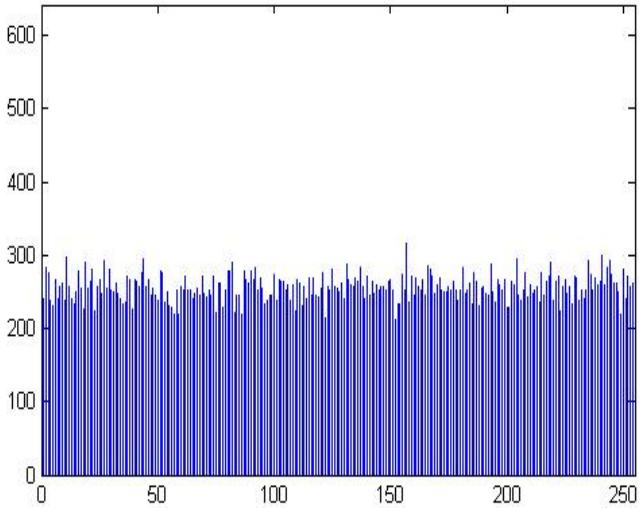
Figure 4: Encrypted image of '*Lena*' and histograms of its *R, G*, *B* components.



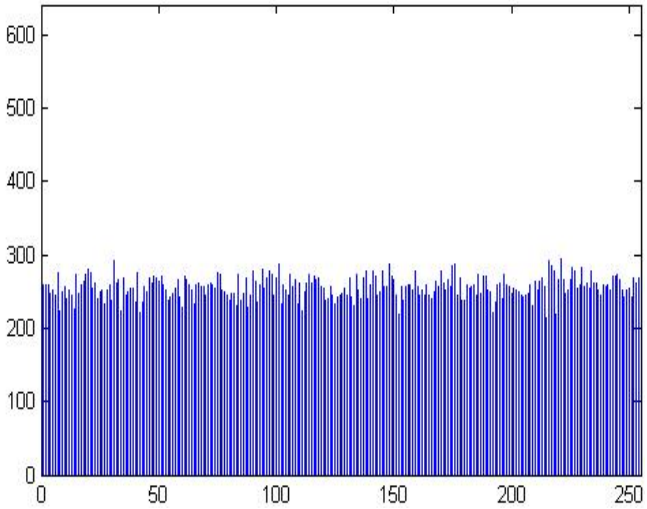
(c) Encrypted image



(d) *R* component



(c) *G* component



(d) *B* component

Table 4: Chi-square values of images

	Red	Green	Blue
Original	65274.12	30609.43	91931.33
Huang *et al.* [20]	12343.32	8570.18	37977.49
Xiao *et al.* [21]	NA	NA	NA
Proposed version	272.30	307.46	218.93

3.4. Correlation Analysis

The correlation between adjacent pixels of encrypted image should be as low as possible. For evaluating the correlation between the pixels in cipher image we randomly select pairs of adjacent pixels in image. The correlation coefficient is calculated as [19].

$$\rho = \frac{N\sum_{i=1}^{N}(x_i \times y_i) - \sum_{i=1}^{N} x_i \times \sum_{i=1}^{N} y_i}{\sqrt{(N\sum_{i=1}^{N} x_i^2 - (\sum_{i=1}^{N} x_i)^2) \times (N\sum_{i=1}^{N} y_i^2 - (\sum_{i=1}^{N} y_i)^2)}} \tag{10}$$

Where x and y are gray values of adjacent pixels and N is the total number of pairs of pixels of an image. The values of correlation coefficients for the proposed and existing algorithm are given in Table 5. The proposed algorithm provides lower value of ρ as compared to existing algorithms, thus our algorithm outperforms both Huang *et al.* [20] and Xiao *et al*. [21] algorithms.

Table 5: Correlation coefficient of pixels in images

	Horizontal	**Vertical**	**Diagonal**
Original	0.9597	0.9792	0.9570
Huang *et al.* [20]	0.1257	0.0581	0.0226
Xiao *et al.* [21]	0.0631	0.0226	-0.0192
Proposed version	-0.00513	0.00339	-0.00373

3.5. Entropy Analysis

Information entropy of an image is a basic criterion used to depict the randomness of data. A greater value of information entropy shows a more uniform distribution of gray values of image. The entropy H of a message source M can be computed as:

$$H(M) = \sum_{i=0}^{255} p(m_i) \log\left(\frac{1}{p(m_i)}\right) \tag{11}$$

Where $p(m_i)$ represents the probability of symbol m_i and the entropy is expressed in bits. If the source $M = \{m_0, m_1, \ldots\ldots, m_{255}\}$ emits 2^8 symbols with equal probability, then the entropy $H(M) = 8$, which corresponds to a true-random source and represents the ideal value of entropy for message source. It is clear that the entropy scores for proposed algorithm are higher and closer to the ideal value than those computed with existing algorithm.

Table 6: Information entropy of images

	Red	**Green**	**Blue**
Original	7.2359	7.5689	6.9179
Huang *et al.* [20]	7.8501	7.9028	7.5582
Xiao *et al.* [21]	NA	NA	NA
Proposed version	7.9970	7.9966	7.9976

3.6. NPCR and UACI Analysis

The NPCR and UACI are two most significant quantities that quantify the strength of encryption algorithms. NPCR is the measure of absolute number of pixels change rate and UACI computes average difference of color intensities between two images when the change in one image is subtle. The NPCR and UACI values can be evaluated by Eqns. (12) and (13), where T denotes the largest supported gray-value compatible with image format, $|\cdot|$ denotes the absolute value function [31].

$$\text{NPCR: } N(C_1, C_2) = \sum_{ij} \frac{D(i,j)}{m \times n} \times 100\% \tag{12}$$

$$\text{UACI: } U(C_1, C_2) = \frac{1}{m \times n} \sum_{ij} \frac{|C_1(i,j) - C_2(i,j)|}{T} \times 100\% \tag{13}$$

$$D(i,j) = \begin{cases} 0 & if \quad C_1(i,j) \neq C_2(i,j) \\ 1 & if \quad C_1(i,j) = C_2(i,j) \end{cases}$$

A pixel of plain-image P_1 is randomly chosen and is set to 0, let this new image be named P_2. Let C_1 and C_2 be the cipher images of images P_1 and P_2. NPCR and UACI values between C_1 and C_2 are calculated for the two schemes and listed in Table 7. Sufficiently high NPCR/UACI scores for C_1 and C_2 are usually considered as strong resistance to differential attacks. The Table shows that a tiny

change in the plain image results almost no change for existing cryptosystem. However, it causes a significantly large difference in proposed method i.e. the proposed version is highly sensitive to a small change in the plain-image.

Table 7: NPCR and UACI between C_1 & C_2

	NPCR			UACI		
	Red	**Green**	**Blue**	**Red**	**Green**	**Blue**
Huang *et al.* [20]	0.0045	0.0030	0.0030	0.00046	0.00114	0.00010
Xiao *et al.* [21]	NA	NA	NA	NA	NA	NA
Proposed version	99.596	99.637	99.577	33.335	33.467	33.563

Now, the NPCR and UACI between P_1 and C_1 are evaluated and listed in Table 8. The scores determine the deviation of encrypted image from its plain-image. It is evident from the comparison that the NPCR values are comparable and UACI scores are significantly better than the scores obtained with existing two algorithms.

Table 8: UACI between P_1 & C_1

	NPCR			UACI		
	Red	**Red**	**Green**	**Blue**	**Green**	**Blue**
Huang *et al.* [20]	99.42	99.60	99.54	24.94	27.66	24.94
Xiao *et al.* [21]	99.54	99.55	99.46	23.91	27.18	23.91
Proposed version	99.63	99.57	99.53	27.56	30.67	27.56

3.6. Resistance to CPA/KPA Attacks

In the proposed version, the generation of shuffling sequences is made dependent to the pending image information in such a way that a tiny different plain-image results in distinct shuffling sequences, which in turn produce totally different encrypted image. Moreover, the components of the pending image are processed collectively and dependently. These improvements make the attacks executed in [22] infeasible and impossible. So, proposed updated version can resist the chosen-plaintext and known-plaintext attacks.

4. Conclusion

In this paper an updated version of color image encryption algorithm has been proposed. The shortcomings of existing technique are eliminated by dynamically changing the shuffling sequences whenever there is a tiny change in plain-image. It is achieved by extracting information specific to the pending plain-image and using it to generate the shuffling sequences. The *R, G, B* components of image are operated collectively and dependently. This guarantees the robustness of the proposed algorithm against CPA/KPA attacks. The statistical features of the algorithm are further bettered by adding a pixel-chaotic-diffusion stage to it, where the diffusion keys are obtained out of the chaotic sequences generated earlier. The NPCR and UACI scores show that proposed version is very sensitive to a slight change in the plain-image. Several other simulation analyses and comparative studies validate the improved security performance of the proposed version.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.394-401
http://www.europeanjournalofscientificresearch.com

Drill-Bit Wear Monitoring Based on Invariant Normalized Central Image Moments

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Abstract

As machining technology has progressed from manually operated production centers to sophisticated CNC machining, automation of the drilling process has gained substantial importance in manufacturing industries. A completely automated drilling environment warrants reliable, timely, in situ monitoring of wear state of the drill-bit, evaluation of the extent of wear and breakage prediction. This paper deals with exploring the role of invariant normalized central moments of images of the drill-bit at various stages of its wear to indicate the presence of tool wear and its extent. The results establish that the normalized central moments are invariant to varying conditions of image acquisition at different wear stages of the drill-bit, but sensitive to tool wear. The seven sets of normalized central moments (second order moments) computed from images captured at different wear points of the drill-bit are used as descriptors to classify the extent of wear.

Keywords: Drill-bit wear monitoring, machine vision, moments, moment-invariance, automated drilling

1. Introduction

Tool wear monitoring is an integral part of automated CNC machining processes. Periodic monitoring of cutting tools for potential premature failures is critical for better machining productivity. This also ensures machining safety through timely replacement of the tool. Indirect measurement schemes determine wear- estimates by monitoring observable parameters related to wear, such as cutting forces, temperatures and vibrations, circumventing the need for interrupting the machining process [28, 32, and 33].In industrial environments, however, the invasive noise signals severely challenge the merit of these estimates.

Direct methods, typically based on machine vision systems, aid in tool-wear measurement by capturing the images of the drill bit at different stages of its life and processing these images using a variety of well-established image processing algorithms. Digital image processing techniques are used in the analysis of images of cutting tool at various stages of its use in order to assess its degree of wear and residual useful life. These are proved to be better in terms of precision, consistency, ease of measurement and the possibility of in-process measurement. Such measures have been shown to

indicate good correlation with the estimated wear characteristics [4,5,7-15,17-21,24]. In the present scenario, machine vision may be considered a mature technology and its application to tool wear monitoring offers many interesting possibilities. Recent advances in the field of image processing technology have led to the development of a variety of in-cycle vision sensors that can provide a direct estimate of the condition of the tool. Such systems are characterized by their measurement flexibility, high spatial resolution and accuracy [22, 23, 26, 27, 30, 31]. The objective of this paper is to propose a scheme to indicate the presence of significant tool-wear and assess the extent of wear in-situ, using moments of images.

2. Drill-Bit Wear Monitoring

Machine vision based drill-bit wear monitoring involves measuring distances between images of drill bits captured at different stages of its life cycle, to determine the extent of wear. This calls for analyzing patterns, patterns that are found in the images captured at different stages of the drill-bit, acquired under different conditions and deformed in various ways. There are essentially three major approaches to this problem – brute force, image normalization, and the use of features of images invariant under different operating conditions, but reflect the changes due to wear. Brute force approach involves generating the space of all possible image degradations. In order to measure the extent of drill-bit wear between two instances, it does not suffice to compare the images acquired at these instances, but also measure the distances between combinations of all their rotated, scaled, blurred, and deformed versions. This approach leads to extreme time complexity and is practically inapplicable.

In the normalization approach, the images of the drill-bit at different instances of use are transformed into some standard position before they are classified. This allows the distances measured between images of the drill-bit at different stages of wear to reflect only the extent of wear, not any other parameters that are of no interest in the context of drill-bit wear measurement. This approach could be very efficient in the classification stage but such normalization procedures generally demands solution of complex inverse problems. The approach using invariant features appears to be the most promising. The fundamental idea is to describe the object by a set of features which are not sensitive to transformations that the images are subjected to during the normal acquisition process, but are sensitive to provide adequate discriminatory power to distinguish them into different classes in the context of wear metrics. We have to find the functional I defined in the space of all admissible image functions which are invariant with respect to degradation Operator D, i.e. which satisfies the condition I(f) = I(D(f)) for any image function f. Non-linear invariant functional, which are composed of various projections of f into the space of polynomials, are used for this purpose. Such projections are known as image moments and the respective functionals are called moment invariants. Several groups of moment invariants exist with respect to the most common degradations – image affine transform (image rotation, scaling and translation) and image blurring.

3. Role of Moment Invariance in Drill-Bit Wear Monitoring

The *normalized* nth central moment is the nth central moment divided by σ^n; the normalized nth central moment of

$$x = \mathrm{E}\left((x - \mu)^n\right)/\sigma^n.$$

Theory of two-dimensional moment invariants for planar geometric figures was introduced by M K Hu in 1962 [34]. Hu established a fundamental theorem to relate moment invariants to algebraic invariants. He derived a complete system of moment invariants, invariant under translation, similitude and orthogonal transformations. The set of normalized central moments (second order moments) of images are shown to be invariant to such linear transformations. This property of moment invariance may be used to compare images of the drill-bit acquired during different stages of its life, for wear or

breakage, with no specific requirement of identical conditions while acquiring these images. Various moments and their properties and their role in recognizing patterns are examined in detail in [6]. M Rizon et al [27] used geometric moment invariant feature vectors that are invariant under shifting, scaling and rotation to extract the global features for pattern recognition due to the discrimination power and robustness of moment invariants. Moment invariants are evaluated as a feature space for pattern recognition in terms of discrimination power and noise tolerance in [22,23,26,27,30,31].The need for using current technology against the conventional measurement methods for the economical influence of tool replacement costs and the use of different moments to describe tool wear images and to classify the tool condition in wear classes has been studied by J Barreiro et al[26] concluded that Hu and Legendre moment descriptors provide the best performance in the context of tool wear monitoring. In this work, the use of invariant moments has been extended to drill-bit wear monitoring. Apart from the discriminatory effect of the second order moments in classifying images of the drill-bit captured at its different usage points in the context of drill-bit monitoring, the interest in image moments stems from the following situation. Generally, vision based drill-bit wear monitoring schemes proposed in literature insist on or assume that the series of images of the drill bit at various stages of its usage, are captured under identical conditions and orientations. These algorithms use mean square error as a measure of image-distance for determining the distance between images of the drill-bit acquired at various stages of its life cycle. This distance measure is used to declare a drill bit as worn or otherwise, as well as to indicate the extent of wear. Changes in the conditions or slight changes in orientations during image capture may lead to image degradations and distortions (such as rotation, scaling, image blurring, etc.). Such distortions introduce distances between images that may not be attributed to drill-bit wear, leading to erroneous measurements.

In practice, it may not be possible to satisfy circumstances of uniform conditions & orientations during the image acquisition process. There is a distinct possibility that as time progresses, at different stages of measurement, the conditions of image acquisition such as lighting and background may differ or the orientation of acquired images may be different due to slight, miniscule shift in the camera position or the position of the drill bit. This leads to the introduction of linear transformations of translation, rotation and scaling between the acquired images, altering the position of the drill bit in the image, though by a few pixel distances. These are not perceptible to human interpretation, but may lead to the introduction of distortion that cannot be attributed to drill-bit wear. The set of second order moments, being invariant to such transformations, is a good candidate to act as a descriptor for measuring drill-bit wear. The property that second order moments are invariant to linear transformations is made use of to neutralize the effects of such distortions occurring between multiple image acquisitions.

3.1. Normalized Central Moments

Moments are descriptors obtained from point coordinates in a region and their gray level. They are applied in several areas of pattern recognition and object classification. Moments and functions of moments are invaluable tools in the literature for the measurement of the properties of a distribution [22, 23, 26, 27, 30, and 31]. In the field of image analysis, their use as image descriptors was pioneered by Hu [34] when he used the 2D geometric moments for characterizing the visual patterns in images. For different images, the respective sets of moments are unique and this makes them particularly useful for the task of pattern recognition. This is further added by the advantage of being able to construct moment invariants which are insensitive to rotation, scaling and translation. Hence, geometrical moments are effective descriptors for images under different perspectives. *Geometric moment* m_{pq} of image $f(x, y)$ of size M x N is defined as

$$m_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} x^p \, y^q \, f(x, y)$$

where p, q are non-negative integers and $(p + q)$ is called the *order* of the moment. The corresponding central moment of order (p+q) is defined as

$$\mu_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (x - x')^p (y - y')^q f(x, y)$$

for p = 0, 1, 2,…. and q = 0, 1, 2,…, where $x' = m_{10}/m_{00}$ and $y' = m_{01}/m_{00}$

The normalized central moments, denoted η_{pq}, are defined as $\eta_{pq} = \mu_{pq} / \mu^{\gamma}_{00}$

where $\gamma = \frac{p+q}{2} + 1$ for p+q = 2, 3….

Hu[34] derived seven invariant moments using nonlinear combinations of normalized central moments:

$\Phi_1 = \eta_{20} + \eta_{02}$

$\Phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta^2_{11}$

$\Phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2$

$\Phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2$

$\Phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} - \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$

$\Phi_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$

$\Phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{12} - \eta_{30})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$

The above mentioned set of seven moment invariants is insensitive to rotation, scale change, mirroring and translation.

4. Machine Vision System

Machine vision based drill bit wear monitoring involves using certain distortion measures to measure the distance between images of drill bits captured at different stages of its life cycle. These distances are indicative of the extent of wear. The system typically consists of a fiber-optic light source to illuminate the tool and a CCD camera (used in conjunction with a high resolution video zoom microscope), to capture the reflected pattern. The software would include implementation of machine vision algorithms to process the images to indicate the presence of wear and its extent. The images of the drill bit at different stages of its life are captured using the experimental set up - a CCD camera used in conjunction with a high-resolution video zoom microscope. These images are processed for removal of background noise and further subjected to edge enhancement and segmentation to retain only the critical regions of interest. This ensures that the images are enhanced to retain the information required for further processing and suppress the information that is not relevant in the context of wear analysis.

5. Cluster Analysis

The pre-processed images of the drill-bit are further described by means of statistical moments. The set of seven normalized second order moments as described in section 3 are computed for each of the images acquired at different stages of tool wear. The main wear classes may be determined by analyzing these moment information. Traditionally, finite element models, neural networks, and more recently data mining techniques are used for analyzing the moment data. J. Barreiro et al suggest [2] that the data mining approach would be the most natural choice based on the dimensions and cardinality of the data set that is being analyzed. Amongst the various techniques in the field of data mining, cluster analysis techniques is a tool that is typically used for solving many classification problems.

Cluster analysis is an exploratory data analysis tool for solving classification problems. Its object is to sort cases (people, things, events, etc) into groups, or clusters, so that the degree of association is strong between members of the same cluster and weak between members of different clusters. Each cluster thus describes, in terms of the data collected, the class to which its members

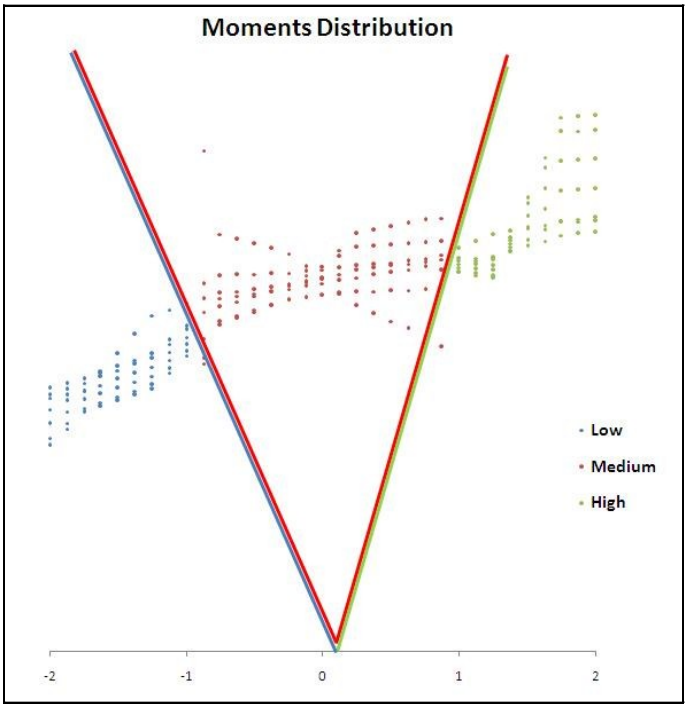
belong [36].In the context of drill-bit wear analysis, it is used as the statistical method to partition the seven sets of invariant second order moments of the drill-bit acquired at various stages of its drilling life into three classes of low, medium and high wear. K-Means clustering is used in this work. This technique attempts to find user-defined number of clusters (K) that are represented by their centroid [26].The term cluster analysis encompasses a number of different algorithms and methods for grouping objects of similar kind into respective categories. In other words cluster analysis is an exploratory data analysis tool which aims at sorting different objects into groups in a way that the degree of association between two objects is maximal if they belong to the same group and minimal otherwise. Cluster analysis can be used to discover structures in data without providing an explanation or interpretation. In other words, cluster analysis simply discovers structures in data without explaining why they exist. There are number of methods for analyzing clusters. This thesis makes use of the Expectation Maximization (EM) method for analyzing the clusters formed by the Hu-moments of the digital images of the drill-bit. While K-means clustering assigns observations to clusters to maximize distance between clusters, the EM algorithm works on the basis of classification probabilities. Each data would belong to every cluster with certain probability and the final assignment of the data to individual clusters would be based on the largest probability. The actual moment values were normalized further using absolute logarithm to reduce the dynamic range making the plotting compact.

6. Results and Discussions

The experiment involved using a drill-bit for drilling holes on a work piece and capturing images corresponding to various stages of the life of the drill-bit. Fifty stages were considered during the life of the drill-bit and two sets of fifty images were captured after a few trials. The first set represents the side view of the drill bit with top lighting. This gives the details of the wear of the land and the moments are greatly affected by the color and texture of the flute which is subjected to changes depending on the machining parameters such as feed rate. The second set is of the side view of the drill bit with top lighting giving the details of the point angle which generally decreases as the tool is utilized for a number of trials.

The seven sets of the second order moments as described by Hu [34] are computed for each image, giving us two sets of seven moment values for each of the fifty stages of the drill bit. The two sets of data analyzed using the K-means clustering algorithm refined further by the Expectation Maximization algorithm confirms that the seven sets of second order moments vary significantly for different images at different wear points of the drill-bit and may be classified into three classes – low, medium and high wear as seen in figure 1. The changes in the acquisition conditions do not affect the values of the second order moments while the different wear conditions do. This helps to find the presence of wear and the extent regardless of the changes in the image acquisition conditions.

Figure 1: Wear moment's distribution



7. Conclusion

Different authors [1, 3, 16, and 19] emphasized the impact that tool replacement operations have on costs in the metallic parts manufacturing. Tool replacement cost includes costs of cutting tools as well as the costs linked to unproductive time required to measure tool wear and the time required to carry out replacement. Many times, more conservative rules are applied to discard the drill-bit much before it is actually becomes useless to ensure quality of the work piece. In a manual processes, the replacement of the drill-bit is purely based on the human perception, a highly subjective process, In automated lines, replacements are deliberated according to variables such as the elapsed time or number of holes drilled. Such an approach may result in loss of quality of the work piece due to late withdrawal of the tool or cost implications due to sub-optimal usage of the drill-bit. The approaches discussed in this work overcome the above challenges by means of automated continuous monitoring of the tool wear to effect timely replacement of the drill bit, increasing the quality of the end-product and overall productivity. The experimental results were concurred with actual measurements to establish the robustness of the proposed techniques.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.402-411
http://www.europeanjournalofscientificresearch.com

Effectiveness of Health Risk Perceptions Program in Improving Protective Behavior in Pesticides use among Rice Farmers in Sukhothai Province, Thailand

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Abstract

The objective of this quasi-experimental study was to assess the effectiveness of health risk perception intervention program in improving knowledge, attitude, and protective behavior, among 182 rice farmers in Sukhothai province, Thailand. The intervention group comprising 91 rice farmers received 1-month intervention program. Outcomes were measured before intervention (baseline), and at 1 and 4 months after intervention. The effects of intervention were evaluated with difference-of-difference analysis. The result revealed that all the participants participated all follow-up times. After adjusted mean difference, the intervention program improved the knowledge by a mean score 4.2 (95%CI 3.7–4.8; p<0.001) one month after the intervention and by a mean score of 3.5 (95%CI 2.8–4.3; p<0.001) 4 months later, attitude by a mean score of 8.9 (95%CI 6.5-11.4; p<0.001) one month after the intervention and by a mean score of 13.2 (95%CI 8.9–17.5; p<0.001) 4 months later, and protective behavior by a mean score of 8.6 (95%CI 7.4–9.9; p<0.001) one month after the intervention and by a mean score of 6.2 (95%CI 3.9–8.5; p<0.001) 4 months later. Thus, this program should be considered for implementation to improve the risk perception and safe use of pesticide in other rice farm areas.

Keywords: Health Risk Perception Program, Pesticides, Protective Behavior, Rice Farmers, Thailand

1. Introduction

Thailand is currently the leading country in exporting rice products to the world market (Ministry of Agriculture, 2010).Many pesticides are being imported into Thailand for use with commercial planting in agricultural farms, and are sold in market with more than 2000 brand names. However, two types of pesticides are widely used, namely insecticides (51%) and herbicides (38%), although since 1997, 82

kinds of pesticides have been banned in Thailand (IPM, 2005). Use of pesticides is one of the methods that farmers employ to control pests. Pesticide usage has increased in Thailand. The agrochemical expenses in the years 2006, 2007, 2008, and 2009 were 10,530, 12,898, 15,062, and 19,181 million Baht per year, respectively. The volumes of agrochemical imports were as high as 75,473, 95,763, 116,322, and 109,907 tons per year, respectively (Department of Agriculture, 2010). Associations with cumulative exposure have been found to persist after excluding individuals who had a history of pesticide poisoning or had experienced an event involving high personal pesticide exposure. Self-reported neurologic symptoms have been observed to be associated with cumulative exposure to moderate levels of fumigants and organophosphate and organochlorine insecticides, regardless of recent exposure or history of poisoning (Kammel et al., 2005). Although the number of cases of pesticide poisoning in Thailand has decreased from 3109 to 1252 cases since 2000 to 2007, and increased again in 2008 by 1705 cases and in 2009 by 1691 cases, Sukhothai Province in northern Thailand has exhibited decreased incidence from 66 to 34 cases since 2005 to 2007, and increased incidence in 2008 (60 cases) (Bureau of Epidemiology, 2010). Overall, the pesticides used were inappropriate, and the farmers failed to use suitable personal protection, apply pesticides in an appropriate fashion, or discard the waste safely. They frequently relied on commercial advertisements for the best pesticide to use (Plianbangchang, et al 2009), and the use of pesticide has been largely directed by self-behavior. In "political environment in which regulations do not cover how farmers apply pesticides, it is important to know what drives farmer's voluntary behavior of pesticide use" (Lichtenberg and Zimmerman, 1999). An earlier study on the influence of pesticide safety knowledge, beliefs, and intention found that knowledge levels were positively related to intentions, beliefs, and self-efficacy of use of personal protective gear, but were not significantly related to risk perceptions and peer norms concerning pesticide safety (Perry, et al, 2000). Differences in the perceived importance and competence of farmers on the safety measures revealed considerably different needs of farmers for future training as a result of differences in age along with other background characteristics (Hashemi, et al, 2012). A review of the effectiveness of interventions to reduce pesticide overexposure and poisoning in worker populations found that few controlled studies have been carried out (Keifer, 2000). Effective preventive interventions to increase correct perceptions of pesticide use, the use of personal protective measures permanent farm workers were recommended (Kachaiyaphum et al., 2010). Intervention programs regarding safety practices during field work are important issues aimed at minimizing adverse health effects of pesticide (Jintana et al., 2009). Efforts have been taken to increase the knowledge and awareness of the hazard of using pesticide substance, which exhibited little success. Nevertheless, awareness regarding use of good protection during pesticide application should be created through cooperation among rice farmers. The objective of the present study was to test the effects of health risk perception intervention program designed to increase knowledge, attitude, and protective behavior in pesticides use.

2. Materials and Methods

2.1. Setting and Participants

This quasi-experiment was carried out from November 2011 to June 2012 at two of the 11 sub-districts of Kongkrailat, Sukhothai province, Thailand. The participants were 182 rice farmers (91 participants in the control group and 91 participants in the intervention group), 18–65 years of age, who employ pesticide application methods such as mixing, loading, spraying, and washing equipments at least once a year, work on rice farm at least once a year, and can read and write. Written informed consent was obtained from all the participants. The study protocol was approved by the ethical committee of Chulalongkorn University, Thailand COA No. 016/2555.

2.2. Procedures

Two sub-districts were purposively selected for the intervention and control group. The distance between the intervention and control areas was about 6 kilometers, comprising both village and farm areas. Both the sub-districts had similar time period of growing rice farms. Evaluation was carried out during two-times follow-up at 1 month and 4 months after intervention. A previous study by Markmee and Chapman (2005) was used as a basis for sample-size calculation. A total of 182 subjects were recruited to detect the outcome that might lose 10% follow up (91 subjects in the experimental group and 91 in the control group). Pre-test: The intervention group comprised 91 randomly selected household participants from the 191 participants of all the 430 rice farmer households. The control group included randomly selected 91 household participants from the 165 participants of all the 255 rice farmer households. Questionnaires were developed from the studies by Sorat (2004), jariya (2006), and the Agriculture Health Study of USA (AHS), (2010). Pilot test was used to achieve clarity of questionnaires. Cronbach's alpha protective behavior was 0.72. At a one-day conference, research assistants were hired and trained to administer the questionnaires (conduct questionnaire interviews). Data collection, the participants were follow-up through cooperation with health workers in two health centers and health village volunteers in two sub-districts.

2.3. Health Risk Perception Intervention Program

Health Risk Perception Program was applied based on risk perception by Social Cognitive Psychological Model (CSPM) (Langford et al., 2000) and risk communication model (Rohrman, 1992), including 4-day program; 3 days of workshop, 1-day field application, and learning with colleague workers for four times. ***On the first day***, the messages consisted of pesticide utilization and pesticide problems in Thailand (1 h), pesticide data, protective behavior, and health risk data from data collection at the baseline data (2 h), classification and hazards of pesticides (1 h), and health risk (both acute and chronic health effects; 2 h). ***On the second day***, the message consisted of pesticide information in the label (1 h), route of exposure (1 h), guideline for safe use of pesticides (2 h), and appropriate personal protective equipment (2 h). ***On the third day***, the messages comprised history of pesticide poisoning among participants and emergency first aid for pesticide injury or pesticide poisoning (6 h). ***On the fourth day***, field application of pesticides and group discussions about all activities in the field were carried out, and a summary of the entire program was provided (6 h). Field application aimed to demonstrate participants the advantage of the use of personal protective equipment when using pesticides and how to protect from the hazards when using pesticides.

Learning with colleague workers (group learning for four times) was accomplished in villages by dividing the participants into six groups (15 participants per group). This session comprised social relations to improve social amplification and fright factors to behavioral including 4 sessions. The first session (1.5 h) comprised learning about the major behaviors of participants who had experienced pesticide-related health effects or pesticide poisoning, as well as addressing the questions of why and how to reduce the health risk of pesticide use. The second session (1.5 h) included learning about appropriate personal protective equipment. The third session (1.5 h) comprised learning about some protective behavior to reduce pesticides exposure. The fourth session (1.5 h) summarized the overall program and recommendation. The total duration of the program was 24 h. Attendance evaluations of participants in each session were done by the researcher and research assistances. Materials included pesticide handbooks, posters, and power point presentation. Some activities were done during each day, developed by suggestion from expert from the ninth Bureau of Control and Prevention, Ministry of Public Health. Group discussion and conclusion of the program were implemented to make the participants clear about the program, and then explain the method of follow-up by the interviewer/administrator.

2.4. Outcome and Measurement

The outcomes of the study were knowledge, attitude, and protective behavior. Knowledge in pesticide use scores were developed based on each of its four aspects. The range of possible points was 0 through 20 points. Attitude scores were developed base on each of its five aspects; strongly agree, agree, uncertain, disagree, and strongly disagree. The range of possible points was 0 – 120. Protective behavior (practicing in terms of frequency) scores were developed for each of the four aspects: always, sometime, rarely, and never of self-protection behavior. Total protective behavior scores were 69. The range of possible points was 0 through 69 points.

2.4. Statistical Analysis

Descriptive analysis: Mean, Median, and Standard deviation (S.D.) of the scores were calculated for the socio-demographic, pesticide use behavior, protective behaviors, and symptoms. At baseline, to compare personal characteristics (independent variables) and the outcome of measurement (dependent variables) between the intervention and control groups, independent *t*-test was used to compare continuous data, and Chi-square test was used to compare categorical data. Evaluation, Inferential analysis: The researcher assessed the effects of the intervention on scores at two time points: 1 month and 4 months after the intervention. For each follow-up time, the effect size of the intervention was measured with difference-of-difference analysis using the equation: intervention effect = (mean score at follow-up – mean score at baseline) $_{\text{intervention}}$ − (mean score at follow-up – mean score at baseline) $_{\text{control}}$. We constructed linear mixed models to test statistical significance of the intervention effect at each follow-up time. Unadjusted fixed-effects models included main effects of intervention and each follow-up time, and intervention-time interactions for each follow-up time (total 5 independent variables). In these models, the interaction terms are equal to the intervention effects at the 2 follow-up times. A "repeated" statement, with an unstructured covariance type, was included to adjust for repeated within-subject measurements of outcomes at different times. For all tests, Simple regression was used to identify factors associated with knowledge, attitude, and practice to adjust confounding factors and set the significant at 0.10. For the statistical tests of effectiveness used in this study, the level of significance (alpha) was 0.05.

3. Results

3.1. Participants

All the participants had participated all measurement times. The demographic characteristics and pesticide use of the experimental and control groups are shown in table 1 and 2. The average age and farm size were similar in both the groups. The year of rice farmer, pesticide expended in last year, year of application of pesticides, number of days of pesticide use per year, and duration of each application showed statistically significant difference between the intervention and control groups. The year of rice farmers, year of application of pesticides, and duration of each application were higher in the control group. On the other hand, the average pesticides expended and number of days of pesticide use per year was higher in the intervention group. Chi-square test for categories data was used to compare the characteristics between the control and intervention groups. In both the intervention and control groups, the majority were females. Gender, marital status, education, and family's monthly income had no statistically significant difference between the control and intervention groups. Both the groups had less than four household members. Most of the subjects in the intervention and control groups were married, and most of them had an education level of primary school or less. The frequency of cultivation showed a significant difference between the control and intervention groups.

The control group had farmed three times higher than the intervention group. Most of the intervention and control groups had never been trained (95.6%). All of them had the duty of handling,

mixing, and spraying, and mixed more than three kinds of pesticides. The intervention group mixed pesticides at a level higher than the recommended one. Pesticide use history in rice farms was divided into five classes, including herbicide, insecticide, fungicide, rodenticide, and other pesticides. The herbicides that were frequently used by subjects in the intervention and control groups, respectively, were as follows: glyphosate (98.9 and 89.8%) and 2-4D sodium salt (95.6 and 84.6%).

Table 1: Continues baseline characteristics by intervention status

Characteristic	Control(*n*=91)		Intervention (*n*=91)		*p*-value
	Mean	SD	Mean	SD	
Age (years)	46.0	10.1	43.2	11.9	0.095
Year of rice farmer	28.5	12.1	18.2	11.8	<0.001
Farm size (acre)	13.5	7.1	15.4	11.2	0.171
Pesticide expended in last year (USD)	646.2	542.3	1242.1	1192.3	<0.001
Years of application of pesticide	21.1	8.3	11.9	8.4	<0.001
No. of days of pesticide use per year	18.7	18.1	54.8	60.1	<0.001
Duration of each application (h)	3.8	1.5	3.1	0.9	<0.001

Table 2: Dichotomous baseline characteristics by intervention status

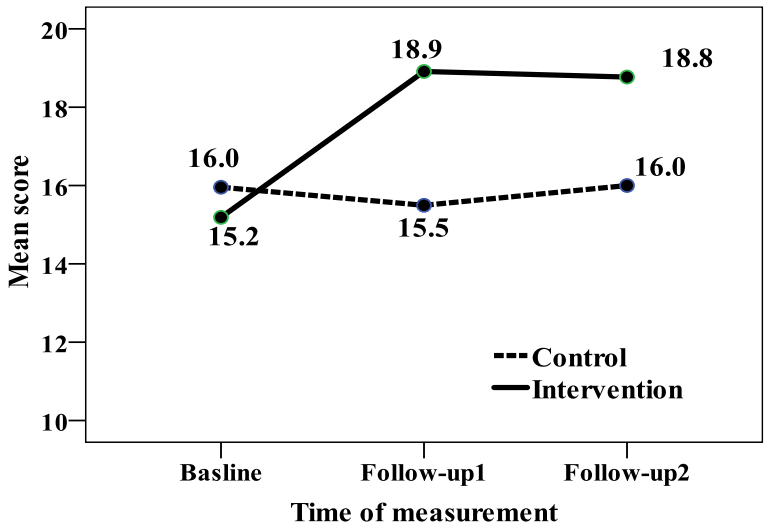
Characteristics	Control (*n*=91)		Intervention (*n*=91)		*p*-value
	n	(%)	*n*	(%)	
Demographic and pesticide use related characteristics					
Male gender	40	44.0	45	49.5	0.458
>four household members	23	25.3	38	41.8	0.019
Married	82	90.1	80	87.9	0.635
Secondary school or higher	30	33.0	27	29.7	0.632
Family monthly income< 333.3 USD	49	53.8	38	41.8	0.103
Cultivation three times per year	42	46.2	22	24.2	0.002
Mix pesticide > recommendation	27	29.7	43	47.3	0.015
Pesticide classification/chemical family name					
Any herbicides	91	100	91	100.0	1.000
Insecticides					
Any organophosphate	90	98.9	91	100.0	0.316
Any carbamate	71	78.0	62	68.1	0.133
Cypermethrin (pyrethroids)	24	26.4	71	78.0	<0.001
Abamectin	90	98.9	90	98.9	1.000
Any fungicides	84	92.3	91	100.0	0.007
Any rodenticides	36	39.6	65	71.4	<0.001
Other pesticides Saponin (bio-pesticide)	14	15.4	19	20.9	0.336
History of exposure by parts of body when using pesticides					
Head and face	66	72.5	53	58.2	0.043
Arms	70	76.9	74	81.3	0.466
Legs	62	68.1	68	74.7	0.325
Feet	49	53.8	73	80.2	<0.001
Inhalation	69	75.8	49	53.8	0.002
Digestive	8	8.8	37	40.7	<0.001

Many of the insecticide chemical family names were used in rice farms by both intervention and control groups. The most common insecticides used by both the groups were chlorpyrefos (control: 89.0% and intervention: 97.8%) and abamectin (control: 98.9% and intervention: 98.9%). Most of them used insecticides by chemical family names, such as organophosphate (OP) and carbamate groups. There was no significant difference between the use of OP and carbamate insecticide family in both the groups. There were no significant differences with respect to bio-pesticide use between the intervention and control groups as shown in Table 2.

3.2. Knowledge, Attitude, Protective Behavior

At baseline, the knowledge and attitude mean scores had significant difference between the control and intervention group. Otherwise, the protective mean scores exhibited no significant difference between the control and intervention groups. At 1 month and 4 months after intervention, the intervention group presented higher mean and total scores knowledge, attitude, and practice than the control as shown in figure 1, 2 and 3.

Figure 1: Mean knowledge scores by intervention status and time (unadjusted)



Overall effectiveness of the program by group activities found that the intervention program had accomplished the practice of wearing plastic gloves during mixing of pesticides and washing hands immediately after mixing. In addition, the intervention program made the farmers to wear hat, use mask, wear goggles, wear boots, and wear plastic gloves during application of pesticides. With regard to practices after application of pesticides, the intervention program was effective in making the farmers clean spray equipments away from the source of utilized water.

Figure 2: Mean total attitude scores by intervention status and time (unadjusted)

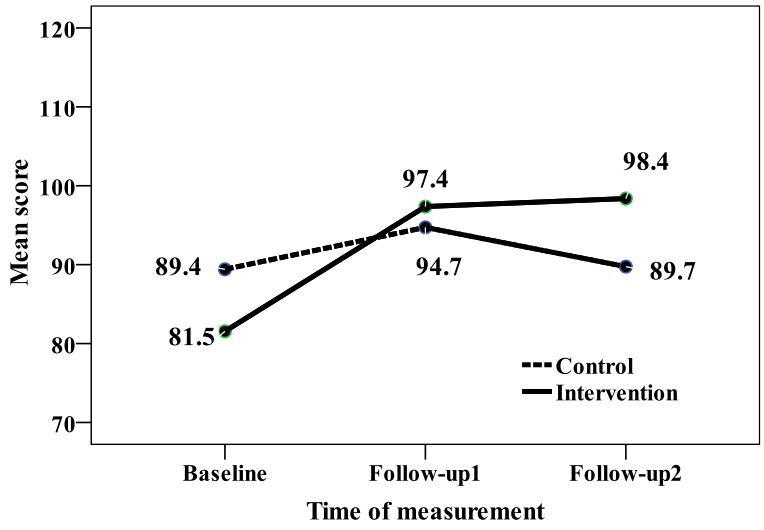
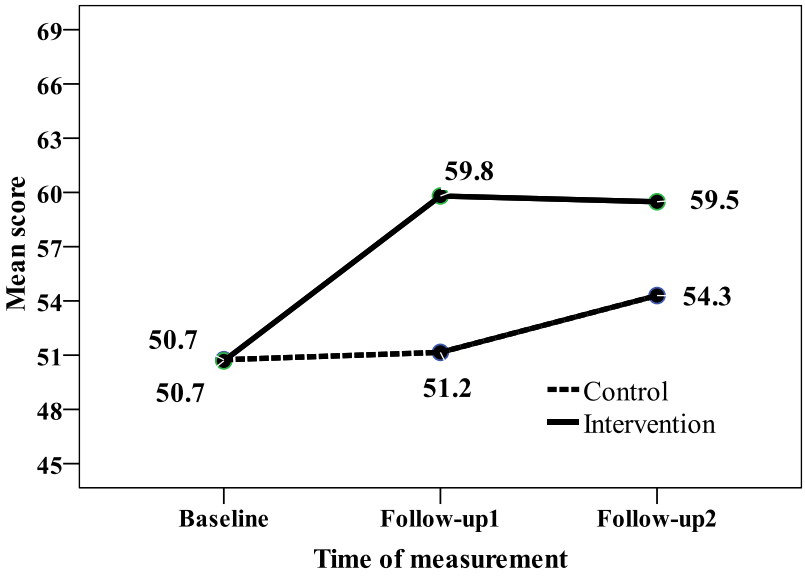


Figure 3: Mean total protective behavior scores by intervention status and time (unadjusted)



3.3. Intervention Effects

Factors association with intervention status were year as rice farmer, year of use of pesticide, number of days of pesticide use, average time each application (hr), income, household member, recommendation, pesticide expend in last year, fungicide use, rodenticide use, history of exposure of head, feet, inhalation, and digestive exposure, cultivation times per year and most recent exposure to pesticide. Simple regression was used to identify factors associated with knowledge, attitude, and practice to adjust confounding factors and set the significant at 0.10. Factors associated with knowledge score were cultivation times per year (p=0.042) and average time each application in hour (0.076). Factors associated with attitude score were pesticide expend (p=0.094), frequency of growing per year (p=0.001), number year use pesticide (p=0.004), day use pesticide per year (p=0.043), average time each applying (p=0.049), most recent expose to pesticide (p=0.004), recommendation (p<0.001), and exposed inhalation (p=0.026). Factors associated with practice score were household members (p=0.003), pesticide expend (p=0.001), day use pesticide per year (p=0.035), any fungicide use (p=0.093), exposed head (p<0.001), exposed feet (p=0.087), exposed inhalation (p<0.001), and exposed digestive (p=0.010). After adjusting mean difference for repeated measure time and confounding factors by general linear mixed model, it was found that the intervention program had improved knowledge by a mean score 4.2 one month after the intervention and by a mean score of 3.5 4 months later, attitude by a mean score of 8.9 at one month after the intervention and by a mean score of 13.2 at 4 months later, and protective behavior by a mean score of 8.6 at one month after the intervention and by a mean score of 6.2 at 4 months later. as shown in table3.

Table 3: Effect size of knowledge, attitude, and practice by intervention status and time

Outcomes	Intervention effect adjusted for confounding factors			
	1 month after end of intervention		4 month after end of intervention	
	Mean change (95%CI)	p -value	Mean change (95%CI)	p -value
Knowledge scores	4.2 (3.7 -4.8)	<0.001	3.5 (2.8 – 4.3)	<0.001
Attitude scores	8.9 (6.5 – 11.4)	<0.001	13.2 (8.9 – 17.5)	<0.001
Practice scores	8.6 (7.4 – 9.9)	<0.001	6.2 (3.9 – 8.5)	<0.001

General linear mixed model, adjusted repeated measure time, and confounding factors

4. Discussion and Conclusions

This quasi-experiment study with control group was design to examine the effective of pesticide risk reduction program in improving knowledge, attitude, and protective behavior of pesticide use among 182 rice farmers in Sukhothai, Thailand. The findings of this study show that the program was effective in improving the knowledge, attitude, and the protective behavior score of pesticide use both 1 month and 4 months after the intervention. Some individually practices in the intervention group were improved in both the measurement times, such as use of mask and gloves when mixing, use of mask, goggles, gloves and wearing hat when applying pesticides. On the other hand, some practices showed less improvement, such as use of coverall and walking backward when spraying.

At baseline, knowledge had relationship with attitude toward using score ($p < 0.001$), attitude toward serious score ($p = 0.005$), and practice score ($p = 0.016$) by Pearson correlation and all direction were positive correlation. World Health Organization (WHO) has mentioned the importance of educating the public as well as agriculture and health-care workers about health risks. Public education programs have been found to increase the farmer' realization of the serious health consequences associated with the rational use of pesticides (Macini et al., 2005); raise awareness of farmers on hazardous pesticide use and encourage them to use low toxic pesticides (Food and fertilizer technology center for the Asian and Pacific region, 2004); reduce the total of pesticides used; increase the use of Personal protective equipment (PPE) (Perry and Layde, 2003); read the pesticide label before pesticide application (Prochaska, 1998); and create awareness among pesticide users on the potential hazard associated with indiscriminate use of pesticides (Mendel et al., 2000). The intervention program was developed base on cognitive social psychological model (CSPM) used for understanding behavior to do with health risk, theorized that behavior decisions are made indirectly based on the relationship between a range factors; attitude, subjective norm, perceived behavior control, and the intention to behave in a particular way. Multidimensional perception of risk was the plan of the intervention program. The messages of the intervention program were particularly designed by the researchers using some of the data from baseline to formative self or cultural background (Langford et al, 2000) in the intervention area, such as pesticides class, family name, and history of pesticide poisoning. The risk communication factors; the audience, messenger, message, medium (Fessenden-Raden et al., 1987) were concern in the intervention program. The messengers were supported by health workers in Kongkrailat public health office, Kongkrailat hospital, and experts from the ninth Bureau of Control and Prevention, Phitsanuloke Province, Ministry of Public Health. Materials included pesticide handbooks, posters, and power point presentation. Field application and learning with colleague workers were implemented, which were different from those employed in other studies. The time period of rice farming was about 105 days. The highest frequency of cultivation was three times per year. Thus, periods of 1 month and 4 months were appropriate to test the effectiveness of the program. Similarly, the time of farming was the first criteria for selected groups of participants.

The improvement of practice in protective behavior scores was the frequency of using personal protective equipment when mixing and when applying such frequency use mask, gloves, goggle, wear boots, wear hat, and wear coverall. Some comfortable person protective equipments such as coverall and boots had been used at immediately one month after intervention, after that the farmers had lower frequency used at 4 month later.

This intervention program should be implemented in other rice farm areas. The success of this program depends on the risk communication factors, including audiences, messages, medium, and messengers. In addition, further studies testing the effectiveness of the intervention programs should evaluate health risk such symptom prevalence by the effects of each pesticide classes or common names such herbicide, fungicide and rodenticide, and some biological of herbicides, insecticides, and fungicides exposure such should be implement. Multi-health risk of pesticides exposure, long term health effects should be concerned. Some personal protective equipment had not appropriate or uncomfortable to use. Occupational authorities should provide appropriate personal protective

equipment and promote the rice farmers to use for preventing their health risk both acute and chronic health effects.

Acknowledgements

We thank all research assistants, experts from the ninth Bureau of Control and Prevention, Ministry of Public Health, all participants, and grant-supporting source by the Thai Fogarty Center (Grant Number:D43 TW007849 Fogarty International Center – National Institute of Health), U.S.A., and College of Public Health Sciences. Chulalongkorn University is gratefully acknowledged.

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European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.412-417
http://www.europeanjournalofscientificresearch.com

US 2006 National Security Strategy: War Promotion

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Abstract

This article observes original ideas of Peter Feaver about public support of war which were elaborated independently and regardless of Government position. The survey determines whether his ideas influenced the US official National Security Strategy (NSS) 2006 that had been developed in the time when US public attitude toward Iraq and Afghanistan wars was significantly important and, if they did, how significant their impact was. In order to answer these questions, the article compares the text of 2006 National Security Strategy with Peter Feaver's working papers and written statements. The investigation gives coverage to role of P.Feaver in NSS 2006 development, not known to the general public.

Keywords: Peter Feaver, National Security Strategy, public support, use of force.

1. Introduction

The September 11th attacks caused a firm, grim and large-scale reaction from the only superpower in the world–the United States of America. After the act of terror, the US proclaimed proactive and assertive defense against future threats including terrorism, spread of nuclear weapons, and tyranny. In the frames of the new active defense strategy, Washington started military operations on two battlefields in Afghanistan and Iraq. It was obvious that active combat actions would inevitably cause a growing number of casualties among American soldiers and and call forth the US society to question the support of war. After George W. Bush reelection the Administration of the President had to explain the great military plans of the Government to the public via new the 2006 National Security Strategy (NSS). In this regard it is interesting to find out whether the professor of Duke University Peter Feaver, whose main research issue is public support of war, had an impact on the 2006 NSS.

2. Peter Feaver's Ideas about Public Support of War

In order to answer the question about Peter Feaver's influence on the National Security Strategy, it is important to study what ideas he elaborated during his academic career.

Peter Feaver's main ideas are described in the article written in collaboration with Cristopher Gelpi and Jason Reifer "Success matters: Casualty sensitivity and the war in Iraq"[1]. Investigating the Iraq experience, the authors argue that "the public is not indifferent to the human costs of American foreign policy, but casualties have not by themselves driven public attitudes toward the Iraq war, and

[1] Gelpi C.,Feaver P., Reifler J. "Casualty Sensitivity and the War in Iraq". International security (Winter 2005-2006), Accessed March 08, 2012, http://www.duke.edu/~gelpi/success.matters.pdf

mounting casualties have not always produced a reduction in public support[2]. The experts prove their positions and come to a more general conclusion that "the public will tolerate significant numbers of U.S. combat casualties under certain circumstances. The Iraq case suggests that under the right conditions the public will continue to support military operations even when they come with a relatively high human cost. Our core argument is that the US public's tolerance for the human costs of war is primarily shaped by the intersection of two crucial attitudes: beliefs about the rightness or wrongness of the war and beliefs about a war's likely success"[3].

The same theses are proved in other Feaver's academic works "Iraq the vote: retrospective and prospective foreign policy judgments on candidate choice and casualty tolerance"[4] and "Let's get a second opinion: international institutions and American public support for war"[5].

P.Feaver paid special attention to public attitude towards international cooperation and sanctioning when employing military force overseas. In cooperation with P.Gepli Professor Feaver came to a conclusion in the article "Let's get a second opinion: international institutions and American public support for war" that UN and NATO approval was highly important for American society and its support of combat operations. It is worth noting that the survey on public perception of multilateral use of force was conducted without UN and NATO data separation. Authors explained this fact by pointing out that "we lacked a strong empirical basis for determining which allies and institutions would be most salient"[6]. However, the circumstance that UN and NATO data were put together in the survey shows that authors equalize both international institutions and do not consider it necessary to differentiate hierarchy between them and to emphasize UN's primary role in it.

Despite P.Feaver recommend receiving international approval, whenever it is possible to gain public support of overseas war, still professor reminds that "in an international environment that remains anarchic at its root, states will remain capable of using military force regardless of the actions of international organizations…"[7] Therefore, the author does not exclude the right of the state to act unilaterally.

3. Peter Feaver's Influence on 2006 National Security Strategy

The evidence that Peter Feaver had an impact on the NSS 2006 can be found in the note for the Secretary of Defense from Under Secretary of Defense for Policy Douglas Feith. Feith mentioned in the document that thoughts on NSS would be sent to Peter Feaver as he occupied the position in National Security Council[8].

The second proof of the direct role of Peter Feaver is seen in the professor's blog where he wrote about his principal role in 2006 NSS creation[9].

The arguments mentioned above show that Feaver did participate in NSS creation, but nothing is said about his specific impact. This question is answered when the main ideas of the National Security Strategy are compared with Peter Feaver's ideas.

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2 Gelpi C.,Feaver P., Reifler J., 8.

3 Ibid.

4 Gelpi C., Feaver P., Reifler J. "Iraq the vote: retrospective and prospective foreign policy judgments on candidate choice and casualty tolerance", Duke University's archive (April 17, 2005), Accessed March 08, 2012, http://www.duke.edu/~gelpi/IraqtheVote.pdf

5 Gelpi C., Feaver P., Reifler J. "Let's get a second opinion: international institutions and American public support for war", Duke University's archive (August 2007), Accessed March 08, 2012, http://www.duke.edu/~gelpi/GGRFSecondOpinion.pdf

6 Gelpi C., Feaver P., Reifler J., 8.

7 Gelpi C., Feaver P., Reifler J., 30.

8 Note for secretary of defense, The Ramsfeld papers (August 10, 2010), Accessed March 08, 2012, http://library.rumsfeld.com/doclib/sp/3636/2005-08-10%20to%20Eric%20Edelman%20re%20National%20Security%20Strategy%20Ideas-%20Memo%20Attachment.pdf

9 A grading rubric for President Obama's national security strategy, Peter Feaver's blog, April 26, 2010, http://shadow.foreignpolicy.com/posts/2010/04/26/a_grading_rubric_for_president_obama_s_national_security_strategy

The document states, "America is at war. This wartime National Security Strategy required by the grave challenge we face – the rise of terrorism fueled by aggressive ideology of hatred and murder, fully revealed to the American people on September 11, 2001. This strategy reflects our most solemn obligations: to protect the security of the American people"[10]. Therefore, the Strategy unambiguously states that United States would be acting like in wartime and combat operations would become a norm for American society.

During wartime casualties would be inevitable: "We have always known that the war on terror would require great sacrifice – and in this war, we have said farewell to some very good men and women…And our work is far from over". This phrase of the document seems to prepare the society for the growing human costs of war, which will be paid for by the US population.

The document predicts future casualties in the aim of terror fighting: "terrorists have used dramatic acts of murder – from the streets of Fallujah to the subways of London – in an attempt to undermine our will. The struggle against this enemy – an enemy that targets the innocent without conscience or hesitation – has been difficult"[11]. Thus, the authors of the document justify combat actions by the reason of protection from future attacks. It means that for US citizens, the unquestionable rightness and purpose of the war is for protection: "we fight our enemies abroad instead of waiting for them to arrive in our country". No one is interested in repeating the 9/11catastrophe; therefore, the USA public will consider a war on terror to be fair and right. Consequently, it is seen that the first "right" condition proposed by professor Feaver for public support of war is observed in the NSS.

The second "right" condition - beliefs about a war's likely success on the battlefield - is carefully reflected in the document as well. The following arguments can prove this thesis:

1. The authors of NSS 2006 pay special attention to and take an advantage of the positive vocabulary. Careful investigation of the document shows that the terms "fight" and "war" are not used without terms "success" and "winning". Applied to the text of NSS, content-analysis method, referring to vocabulary of political science demonstrated that terms "war" and "fight" are used 25 times while "success" and "winning's" number is 31. This tactic is set forth deliberately in order to convince the reader of NSS to think positively and be sure that plans of the President will bring success.

Similarly to "fight" and "war", followed by "success" and "winning", it cannot be a fortuity that a negative "problem" was replaced by a more positive "challenge". It was done on purpose in order to create feelings of success in future conflicts.

2. Achieved success when G.Bush was on his first presidential term is described in the document whenever it is possible.

Thus, Preamble says about eight tangible results of George Bush's team:

1) "We have kept on the offensive against terrorist networks, leaving our enemy weakened, but not yet defeated.
2) We have joined with the Afghan people to bring down the Taliban regime – the protectors of the al-Qaida network – and aided a new, democratic government to rise in its place.
3) We have focused the attention of the world on the proliferation of dangerous weapons – although great challenges in this area remain.
4) We have stood for the spread of democracy in the broader Middle East – meeting challenges yet seeing progress few would have predicted or expected.
5) We have cultivated stable and cooperative relations with all the major powers of the world.

[10] White house, National security strategy (Washington DC: White house, 2006): i, http://www.comw.org/qdr/fulltext/nss2006.pdf

[11] Ibid.

6) We have dramatically expanded our efforts to encourage economic development and the hope it brings – and focused these efforts on the promotion of reform and achievement of results.
7) We led an international coalition to topple the dictator of Iraq, who had brutalized his own people, terrorized his region, defied the international community, and sought and used weapons of mass destruction.
8) And we are fighting alongside Iraqis to secure a united, stable, and democratic Iraq – a new ally in the war on terror in the heart of the Middle East".

Moreover the structure of the document is comprised of seven chapters, each of them consists of parts "successes" and "challenges". "Success" has a purpose to prove that casualties that American society sacrificed in order to be protected are not in vain. It shows that the efforts of the people who were fighting had already brought tangible results and changed the situation for the better not only for Americans. For example, in the Chapter "Aspiration for human dignity" significant results are:

"Afghanistan, the tyranny of the Taliban has been replaced by a freely-elected government; Afghans have written and ratified a constitution guaranteeing rights and freedoms unprecedented in their history; and an elected legislature gives the people a regular voice in their government.

In Iraq, a tyrant has been toppled; over 8 million Iraqis voted in the nation's first free and fair election; a freely negotiated constitution was passed by a referendum in which almost 10 n million Iraqis participated; and, for the first time in their history, nearly 12 million Iraqis have elected a permanent government under a popularly determined constitution"[12].

The "Challenges" reminds that, regardless of achieved successes, it is early to say that the United States has overcome all obstacles on the way to its safety and security and there will be still challenges to come. This is why the Bush Administration plans a certain scheme of actions by which it will eliminate all handicaps in security issues: "Challenges" structure contains clear and concrete steps to achieve the goal. Therefore, the reader of the document is convinced of reality to attain success on the matter. Moreover, the steps themselves also contain positive dynamics to enforce the feeling that success is a reality. For example, the document says that although the North Korea represents a serious danger, there is something that can help solve the problem:"The North Korean regime also poses a serious nuclear proliferation challenge. It presents a long and bleak record of duplicity and bad-faith negotiations. In the past, the regime has attempted to split the United States from its allies. This time, the United States has successfully forged a consensus among key regional partners – China, Japan, Russia, and the Republic of Korea (ROK) – that the DPRK must give up all of its existing nuclear programs. Regional cooperation offers the best hope for a peaceful, diplomatic resolution of this problem"[13].

3. NSS contains a clause about multilateral cooperation in order to gain society's support: "These relations must be supported by appropriate institutions, regional and global, to make cooperation more permanent, effective, and wide-reaching. Where existing institutions can be reformed to meet new challenges, we, along with our partners, must reform them. Where appropriate institutions do not exist, we, along with our partners, must create them. Fifth, we must be prepared to act alone if necessary, while recognizing that there is little of lasting consequence that we can accomplish in the world without the sustained cooperation of our allies and partners"[14] .

This clause is talking about institutions in general, without establishing any hierarchy or classification. It correlates with Peter Feaver position. However, the document says further that "we must be prepared to act alone if necessary, while recognizing that there is little of lasting consequence

[12] White house, 2.
[13] White house, 21.
[14] White house, 37.

that we can accomplish in the world without the sustained cooperation of our allies and partners"[15]. This clause is connected properly with Pater Feaver's works as well.

4. Conclusion

Ongoing operations in Afghanistan and Iraq, as well as the proactive defense strategy, raise an essential question about public support of war for George Bush's second term Administration. In preparing 2006 National Security Strategy the President was to explain his strategy and gain support from American society. This task was successfully resolved with the help of Duke University professor Peter Feaver, whose main research item lays in the sphere of civil military relations, precisely public tolerance, and support of combat operations abroad.

Peter Feaver states that American perception and support of war adheres to definite regularities. American society will continue to support military operations even when they mean significant numbers of US combat casualties. In order to receive public support, the author suggests that the leaders of the country implement some "right" circumstances. Under the "right" circumstances Peter Feaver offers to provide conditions when society is sure that a military operation is just and fair and confident that war will most likely bring success.

The combination of these public perceptions will guarantee public support of military operation to US leaders and tolerance to relatively high human cost of war.

The 2006 National Security Strategy was created based on Peter Feaver's recommendations.

Firstly, the Strategy justifies the necessity to deploy military personnel abroad and use of force by the need to protect American society from existential threats. The document appeals to 9/11 terror act which is a vital example of the catastrophe Americans do not want to go through again. Then the document leads the reader to an idea that in order to be protected and prevent another catastrophe, Americans should act firmly and cope with the problem before it reaches the US borders. Therefore, American losses incurred in military operations will be presented to Americans as a just and inevitable sacrifice, making American society believe in the rightness of the war.

Secondly, NSS pays special attention to success and the reality to achieve it in the future:

1. The Strategy relies upon positive vocabulary. NSS never uses expressions "war" and "fight" without mentioning "win" and "success" at the same time. Additionally the term "problem" was replaced by the positive "challenge" in order to convince the reader of the reality of success achievement.
2. The structure of the Strategy has an aim to persuade the reader in success of future operations. Each Chapter of the NSS consists of parts called "successes" and "challenges". The "success" certifies achieved positive results. Part "challenges" is deemed to remind the reader about existing problems in security sphere. At the same time, a clear plan of actions that treats the problem as a challenge to overcome makes the reader feel that success on the matter is real.

References

[1] Gelpi C., Feaver P., Reifler J. "Iraq the vote: retrospective and prospective foreign policy judgments on candidate choice and casualty tolerance". Duke University's archive, April 17, 2005. http://www.duke.edu/~gelpi/IraqtheVote.pdf

[2] Gelpi C., Feaver P., Reifler J. "Casualty Sensitivity and the War in Iraq". International security, winter 2005-2006, Vol. 30, No. 3, 7-46. http://www.duke.edu/~gelpi/success.matters.pdf

[15] Ibid.

[3] Gelpi C.,Feaver P., Reifler J. "Let's get a second opinion: international institutions and American public support for war". Duke University's archive, August, 2007. http://www.duke.edu/~gelpi/GGRFSecondOpinion.pdf

[4] Note for secretary of defense. The Ramsfeld papers, August 10, 2010. http://library.rumsfeld.com/doclib/sp/3636/2005-08-10%20to%20Eric%20Edelman%20re%20National%20Security%20Strategy%20Ideas-%20Memo%20Attachment.pdf

[5] Peter Feaver's blog. http://shadow.foreignpolicy.com/blog/2195

[6] White house. National security strategy (Washington DC, White house, 2006), 54. http://www.comw.org/qdr/fulltext/nss2006.pdf

European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 98 No 3 March, 2013, pp.418-434
http://www.europeanjournalofscientificresearch.com

Finite Element Modeling of Reinforced Concrete T-Beams with Multiple Web Openings

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Abstract

In this study, a three-dimensional nonlinear finite element analysis using ANSYS 12.1 program had been employed to simulate simply supported reinforced concrete T-beams with multiple web openings. Three design parameters were considered, including number of web openings, opening shapes and size of circular openings. Fifteen models of simply supported reinforced concrete T-beams were loaded monotonically with one incremental concentrated load. Beams were simulated to obtain the load-deflection relationships, ultimate loads and crack patterns and compared them with the solid reference one. Three experimental T-beams were considered in this study. All models had an identical cross-section and span similar to those of the experimental beams. The diameter of the circular openings of the experimental beams was 110mm. Four other diameters were varied (50, 70, 90 and 130) mm. Equivalent square and rhombus openings in area to the circular openings with diameter =110mm (i.e. f Side length=97.5mm) were studied. Four and six openings in each case were investigated. Results obtained from this study showed that the behavior of beams with circular openings of diameter equal to 22% the web depth has small effect on the ultimate capacity of the reinforced concrete T-beams. On the other hand, introducing circular openings with diameter equal to or more than 30% the web depth reduces the ultimate load capacity by at least 21%. Results also showed that beams with rhombus openings have the highest ultimate loads as compared with the two other shapes, circular or square openings, and beams with circular openings have ultimate loads greater than those with square openings.

Keywords: Concrete beams, multiple web openings, finite elements, modeling.

1. Introduction

Web openings in beams are essential to provide a convenient passage of service ducts and pipes. As a results, story height in buildings can be reduces and slight reduction in concrete beams weight would improve the demand on the supporting frame both under gravity loading and seismic excitation which resulting in major cost saving.

Size of opening did affect strength, but an unreinforced web containing a square opening of one-quarter the web depth, or a circular opening of three-eighths the web depth, did not reduce the strength of the specimen (ASCE-ACI Committee 426). According to Somes and Corley (1974), a circular opening may be considered as large when its diameter exceeds 0.25 times the depth of the web because introduction of such openings reduces the strength of the beam. Siao and Yap (1990) showed that when no additional reinforcement is provided in the members above and below the opening (chord members), the beams fail prematurely by sudden formation of a diagonal crack in the compression chord. Mansur et al. (1991) made an investigation on eight reinforced concrete continuous beams, each containing a large transverse opening. Their study showed that an increase in the depth of opening from 140 mm to 220 mm led to a reduction in collapse load from 240 kN to 180 kN. Abdalla et al. (2003) used fiber reinforced polymer (FRP) sheets to strengthen the opening region in an experimental program. Thompson and Pessiki (2006) conducted an experimental study to investigate the precast, prestressed inverted-tee girders with large web openings.

At the present time, many methods for analyzing reinforced concrete members are available. One of the most powerful methods is the finite element technique which spares much time and efforts. Even though many experimental studies have been reported, no research study has been done on reinforced concrete T-beam with multiple web openings by simulation. In order to verify the finite element model, three experimental beams (a solid beam without openings and two other beams with four and six un-strengthened circular openings provided in the study of Oukaili and Shammari (2013)) were considered in this study.

2. Objectives and Scopes

The purpose of this study is to investigate the effect of number, size and shapes of multiple web openings on the behavior of reinforced concrete T-beams without strengthening of the openings by additional reinforcement. This research study focuses on three variables:

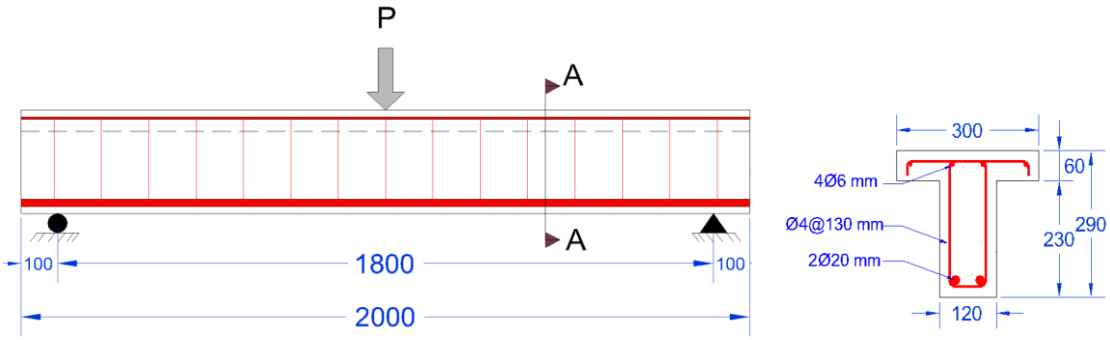
1. Number of openings (four or six openings).
2. Size of circular web openings (50, 70, 90, 110 and 130) mm.
3. Comparison between circular openings with diameter =110mm and equivalent square and rhombus openings in area (i.e. side length w = 97.5mm).

The scope of this study is to simulate simply supported reinforced concrete T-beams with the mentioned variables loaded monotonically with an incremental concentrated loads using ANSYS 12.1 program to obtain load-deflection relationships, ultimate loads and crack patterns and compare them with the solid beam.

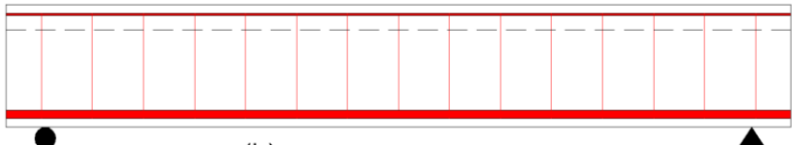
All T-beams had identical dimensions and reinforcement based on Oukaili and Shammari (2013) experimental beams. Thickness of flange =60mm, width of flange =300mm, depth of web =230mm and width of web =120mm. Beam length =2000mm with an effective span =1800mm. All beams were reinforced with two Ø 20mm longitudinal bars as tension reinforcement, four Ø 6 mm longitudinal bars as compression reinforcement and Ø 4 mm at 130 mm center to center as stirrups. The dimensions and details of reinforcement are shown in Figure 1a.

Figure 1b-d shows the details of the experimental beams considered in this study. The distance between the end of the first opening (near the support) and the support equal to 130 mm, this is about half the effective depth. The centers of the circular openings were situated in 145 mm along y-direction from soffit of the beam. Diameter of all openings is 110mm and the clear distance between two successive openings is 160mm. Material properties for concrete and steel of the experimental beams are given in Table 1.

Figure 1: Details of the experimental beams.

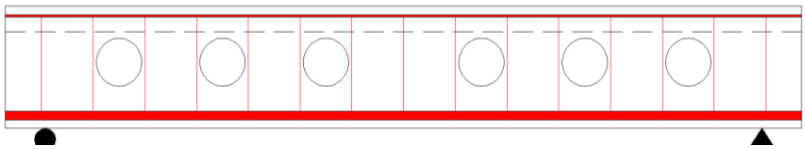


a. Dimensions and reinforcement details of experimental beams.



b. Solid beam (first experimental beam).

c. Beam with four circular openings (second experimental beam).



d. Beam with six circular openings (third experimental beam).

Table 1: Properties of materials

Material	Diameter mm	Compressive strength MPa	Yield strength MPa	Tensile strength MPa	Modulus of elasticity GPa
Concrete	---	27	---	3.2	23
Steel	20 6 4	--- --- ---	600 420 400	747 570 553	200

3. Models Specifications

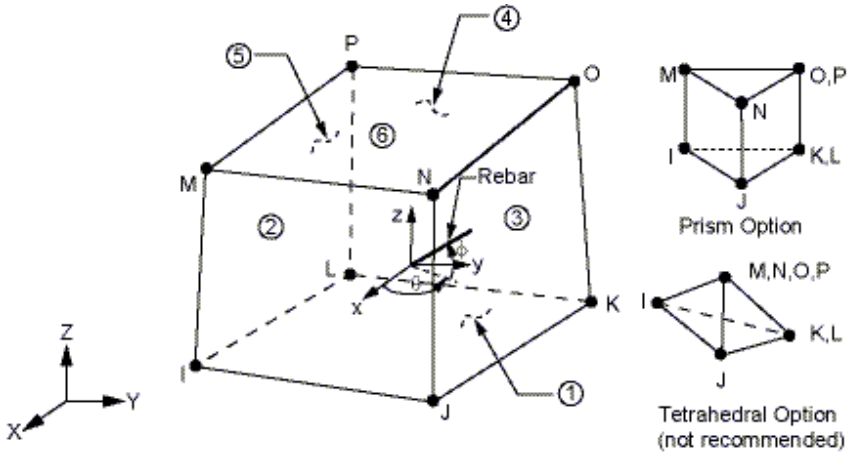
3.1. Materials Properties

3.1.1. Concrete

Concrete is a quasi-brittle material and has different behavior in compression and in tension. Solid65 element was used to model this material. This element has eight nodes with three degrees of freedom at

each node - translation in the nodal x, y, and z directions. This element is capable of plastic deformation, cracking in three orthogonal directions, and crushing. A schematic of the element is shown in Figure 2 (ANSYS Manual, Version 12.1). Smeared cracking approach has been used in modeling the concrete in the present study (William and Wranke, 1975). Poisson's ratio (ν) for concrete was assumed to be 0.2 (Bangash, 1989) .Concrete properties given in Table 1 were considered in this study.

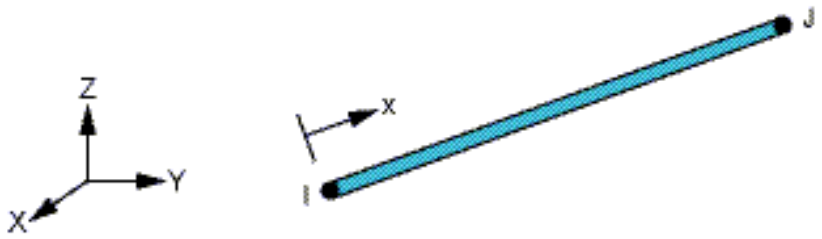
Figure 2: Solid 65 element geometry.



3.1.2. Reinforcement

Modeling of reinforcing steel in finite elements is much simpler than the modeling of concrete. A Link 8 element was used to model steel reinforcement. This element is a three dimensional spar element and it has two nodes with three degrees of freedom -translations in the nodal x, y, and z directions. This element is also capable of plastic deformation. This element is shown in Figure 3. A perfect bond between the concrete and steel reinforcement is considered. However, in the present study the steel reinforcing was connected between nodes of each adjacent concrete solid element, so the two materials shared the same nodes. The steel for the finite element models is assumed to be an elastic-perfectly plastic material and identical in tension and compression. A Poisson's ratio of 0.3 is used for the steel reinforcement.

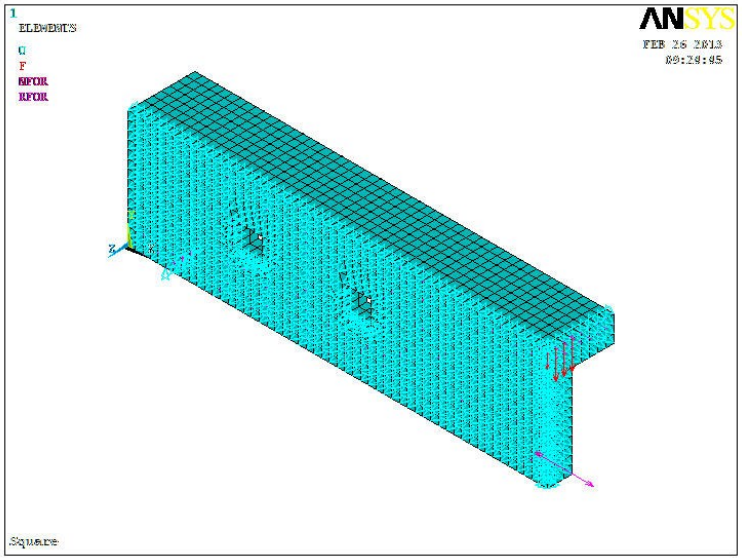
Figure 3: Link 8 element geometry



3.2. Boundary Conditions and Loading

Boundary condition is needed to be applied at nodes in the support to ensure that the modeled beams simulated in the same way as the experimental beams. The load was applied at mid span of the beam on nodes; these nodes extend a distance equal to the web width in order to avoid flange failure. By taking advantage of the symmetry of both beam's geometry and loadings, a quarter of the entire model beam was used for finite element analysis. The finite element mesh, boundary conditions and loading regions of all beams are shown in Figure 4.

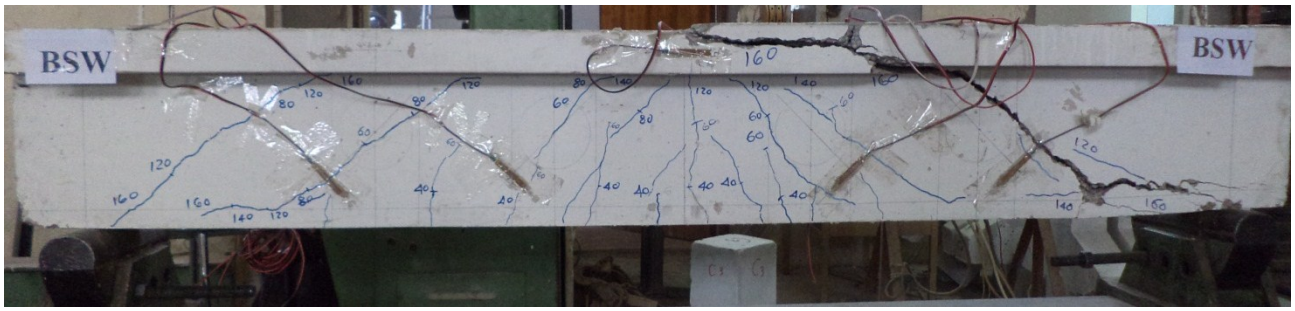
Figure 4: Finite element mesh, boundary conditions and loading regions for a quarter beam model.



4. Verification Study

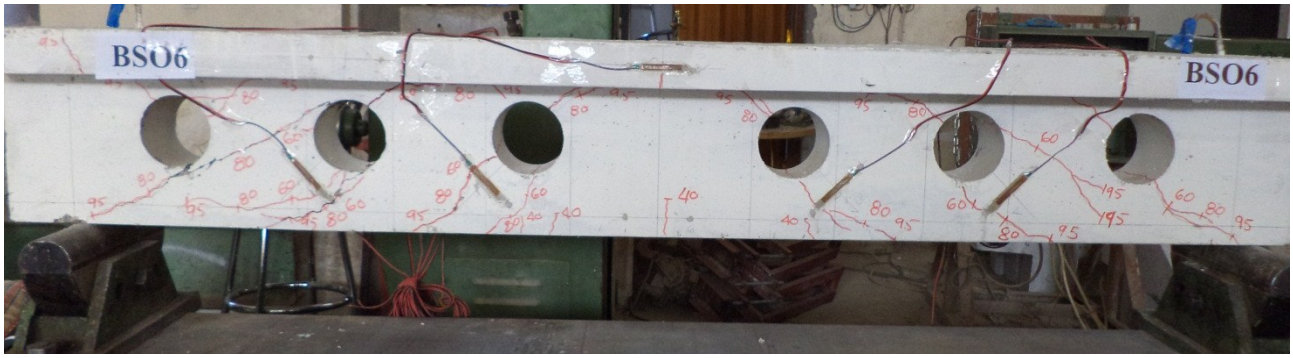
The finite element analysis calibration study includes modeling of reinforced concrete T-beams with dimensions and properties corresponding to solid beam and two other beams with four and six circular web openings of diameter =110mm tested by Oukaili and Shammari (2013). The aim of the comparison of the finite element models and the beams of Oukaili and Shammari (2013) is to ensure that the elements, material properties and convergence criteria are adequate to model the response of the beams and to be sure that the simulation process is correct, these experimental beams are shown in Figure 5

Figure 5: Beams tested by Oukaili and Shammari.



a. Solid Beam (first experimental beam)

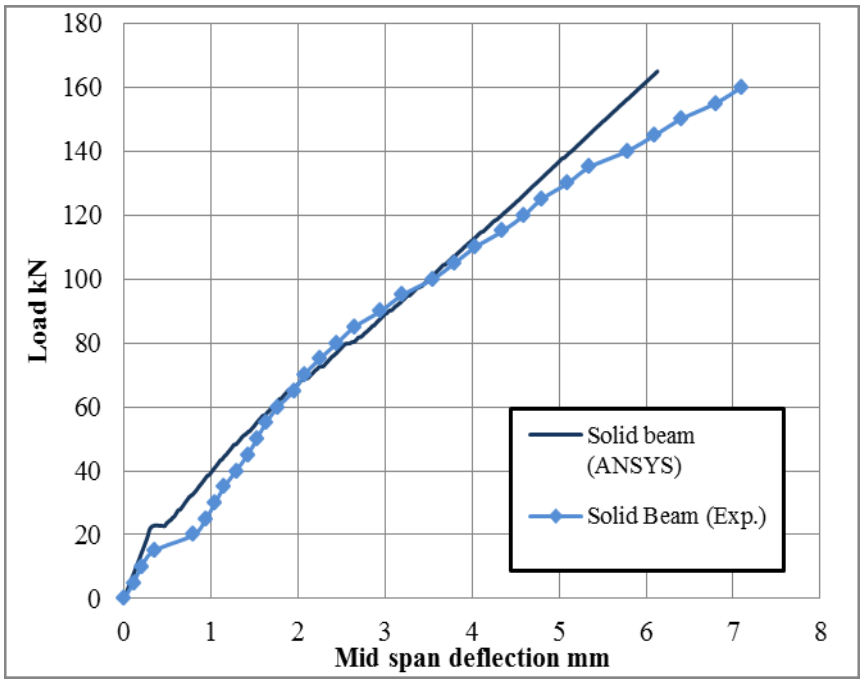
b. Beam with four circular openings, diameter =110mm (second experimental beam).



c. Beam with six circular openings, diameter =110mm (third experimental beam).

For the first experimental beam, solid beam, the ultimate load obtained from the test was 160 kN, while the ultimate load obtained from ANSYS analysis was 165 kN, therefore the difference is about 3% and this proves that ANSYS program is an appropriate method to predict the behavior of reinforced concrete T-beams. Figure 6 shows the load-deflection relationships of the modeled beam and the experimental one.

Figure 6: Load-deflection relationships for the solid beams (first modeled beam and experimental one).



For the second and third experimental beams, beams with four and six circular openings with diameter =110mm, the ultimate loads obtained from tests were 112kN and 95 kN respectively while the ultimate loads obtained from ANSYS analysis were 116 kN and 100kN respectively ,the difference is about 4% and 6% which were considered good results. Figures 7-8 show the load-deflection relationships for these simulated beams with the experimental beams.

Figure 7: Load-deflection relationships for beams with four circular openings (second modeled beam with the experimental one).

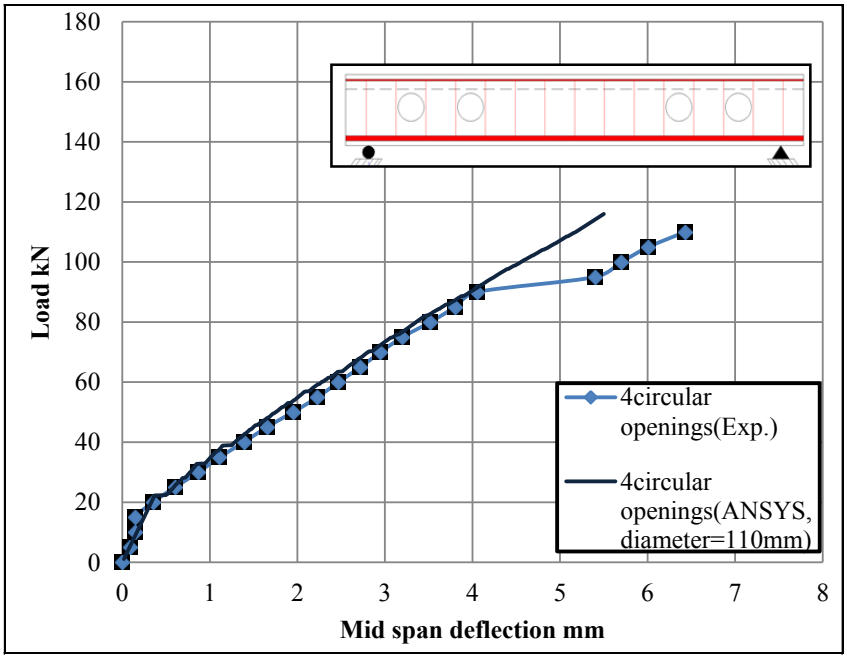
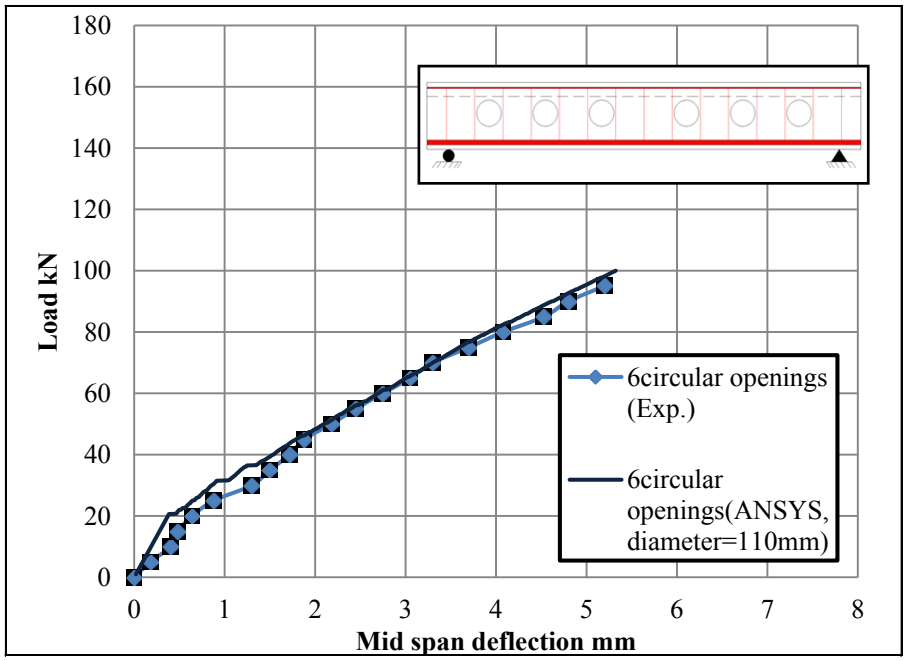


Figure 8: Load-deflection relationships for beams with six circular openings (third modeled beam with the experimental one).



Crack patterns of the three previous modeled beams are shown in Figures 9-11. It can be noticed that the solid beam failed in shear mode, shear cracks extended between the point of load and supports, and the other two beams failed in shear at opening regions.

Figure 9: Crack patterns for the modeled beam 1 (solid beam).

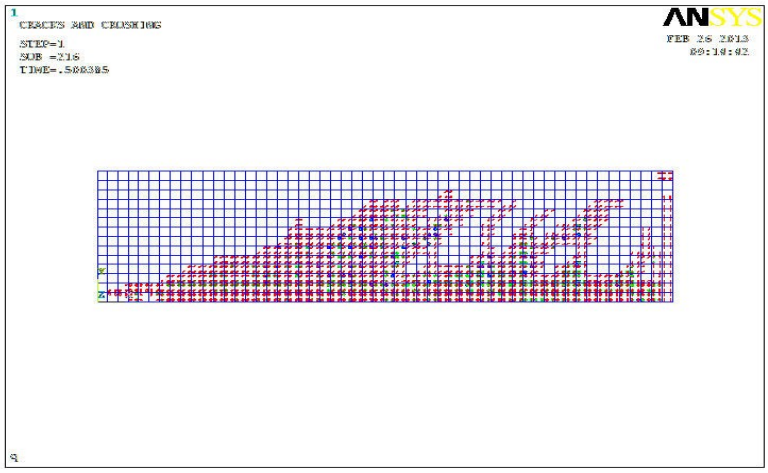


Figure 10: Crack patterns for modeled beam 2 (with four circular openings of diameter=110mm

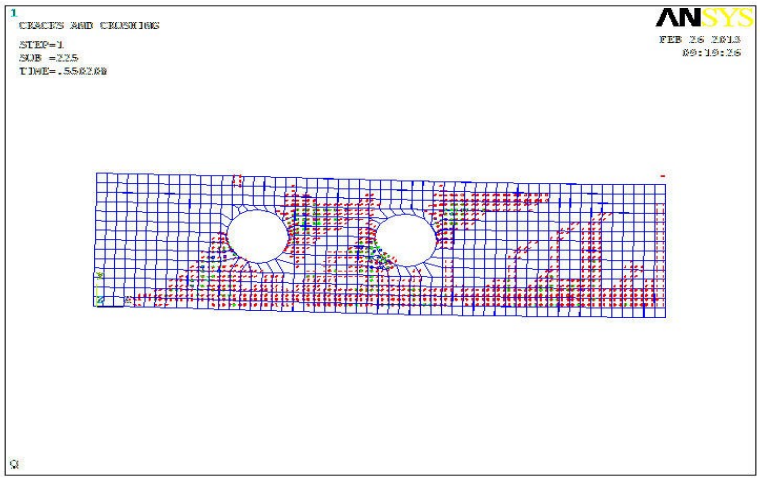
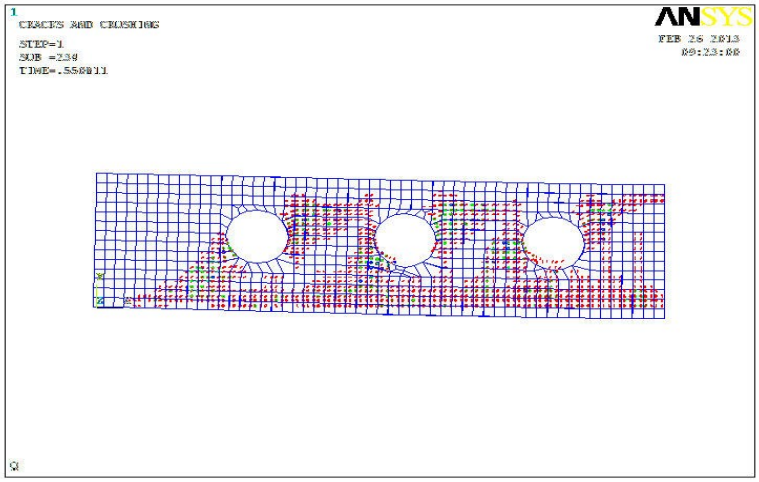


Figure 11: Crack patterns for modeled beam 3 (with six circular openings of diameter=110mm)



5. Results and Discussions

Results and discussion can be divided into two sections. In the first section, the finite element modeling of the reinforced concrete beams with circular openings in varying diameters (50, 70, 90and 130mm) will be discussed and in the second section, the comparison will be made between circular openings (diameter= 110mm) and equivalent square and rhombus openings in area (w=97.5mm). These beams have the same dimensions as the experimental beams tested by Oukaili and Shammari (2013). Twelve additional models were needed for this study and given in Table 2.

Table 2: Properties of the modeled beams

Modeled beam No.	Properties
4	4 circular openings, diameter =50mm
5	6 circular openings, diameter =50mm
6	4 circular openings, diameter =70mm
7	6 circular openings, diameter =70mm
8	4 circular openings, diameter =90mm
9	6 circular openings, diameter =90mm
10	4circular openings, diameter =130mm
11	6 circular openings, diameter =130mm
12	4 square openings, w=97.5mm
12	6 square openings, w=97.5mm
14	4 rhombus openings, w=97.5mm
15	6 rhombus openings, w=97.5mm

5.1. Effect of Size of Circular Openings with Varying Numbers

5.1.1. Modeled Beams 4 and 5

Modeled beams 4 and 5 were with four and six openings respectively, the diameter of these openings is 50 mm. The load-deflection relationships of these models with that of the solid beam, which obtained from ANSYS, are shown in Figure 12. The predicted values of ultimate load capacity from ANSYS analysis were 160 kN and 157 kN for models 4 and 5 respectively. The corresponding value for the solid beam, from ANSYS, was 165 kN. The reductions in the ultimate load capacity were 3% and 5%. Hence, introducing openings with diameter equal to 22% the web depth of the beam has small effect on the capacity of the beam.

Crack patterns of models 4 and 5 are shown in Figures 13-14, from these figures, it can be noticed that the behavior of the beams with multiple web openings with diameter equal to or less than 22% the web depth of T-beam is the same as the solid beam.

Figure 12: Load-deflection relationships for modeled beams 4, 5 and 1 (solid beam).

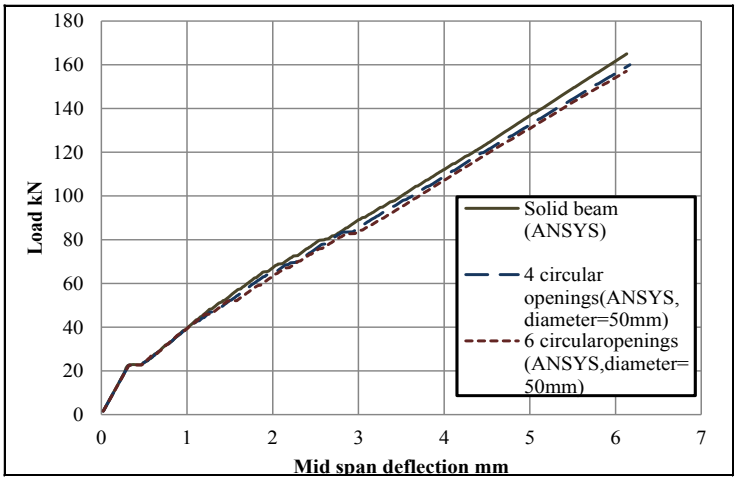


Figure 13: Crack patterns for model 4.

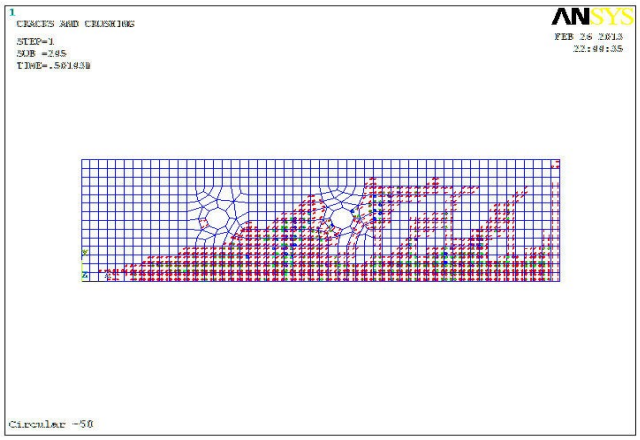
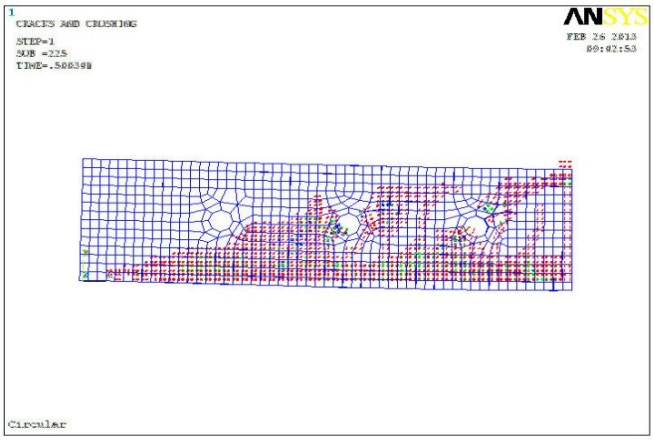


Figure 14: Crack patterns for model 5.



5.1.2. Modeled Beams 6, 7 and 8, 9

Modeled beams 6 and 8 contain four circular openings with diameter of 70 mm and 90 mm respectively while models 7 and 9 contain six circular openings with diameter of 70 mm and 90 mm respectively. Figure 15 shows the load-deflection relationships for the solid beam and those of models 6 and 7 while Figure 16 shows the load-deflection relationships for the solid beam and those of models 8 and 9. The predicted values of ultimate load capacity for models 6, 7, 8, and 9 from ANSYS analysis were 130, 120, 122 and 109 kN respectively. The corresponding value for the solid beam was 165 kN, therefore the reduction in the beam capacity were 21%, 27%, 26% and 34% when four openings (diameter = 30% web depth), six openings (diameter=30% web depth), four openings (diameter=39% web depth and six openings (diameter=39% web depth) were introduced respectively.

Figure 15: Load-deflection relationships for model beams 6, 7 and 1 (solid beam).

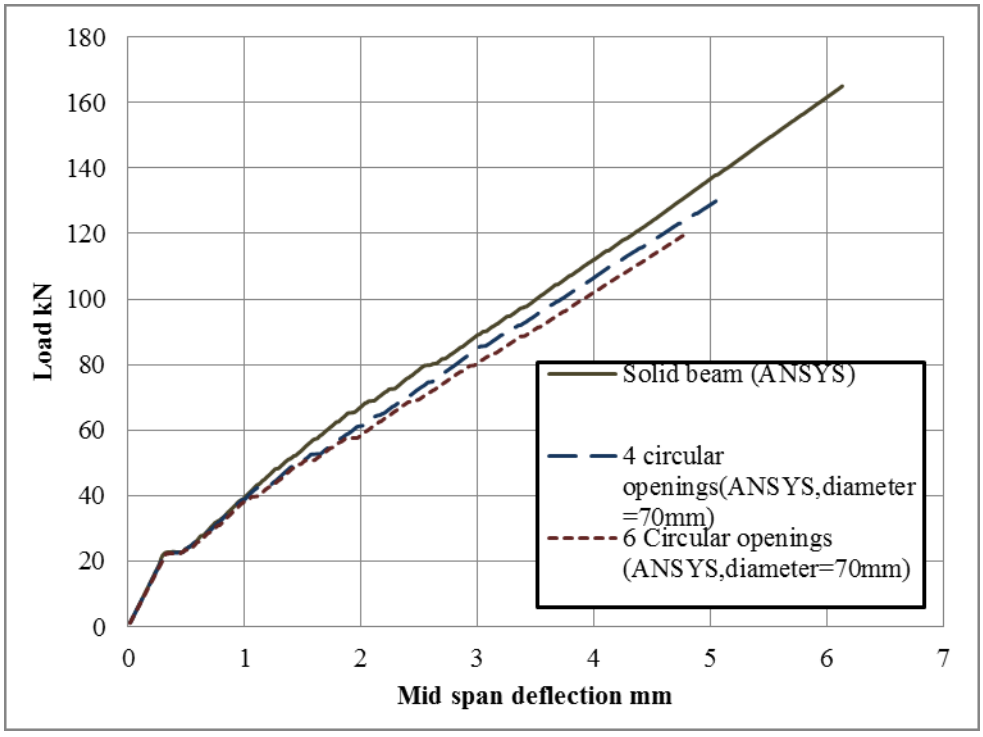
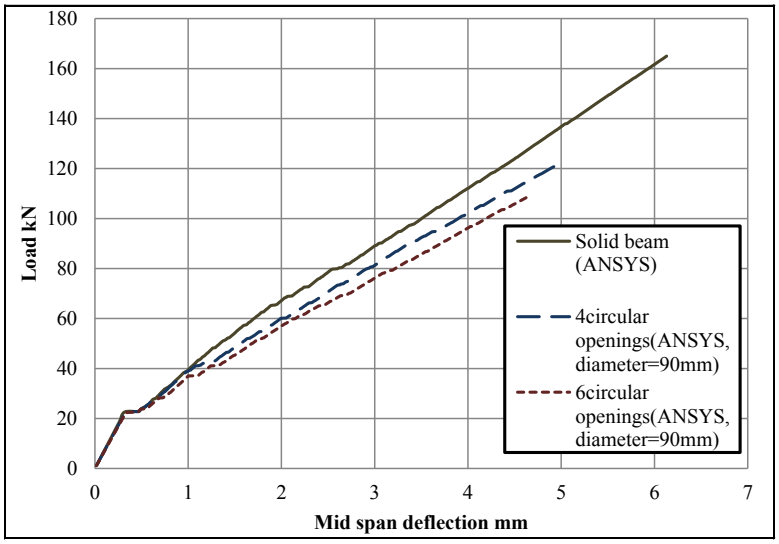


Figure 16: Load-deflection relationships for modeled beams 8, 9 and 1(solid beam).



Crack patterns for models 6, 7, 8 and 9 are shown in Figures 17-20. The diagonal cracks generally appear at the top and bottom corners of the web openings towards the load point and the supports as described by Yoo et al. From Figures 17-20, it can be concluded that the failure mode is in shear at the opening regions.

Figure 17: Crack patterns for model 6

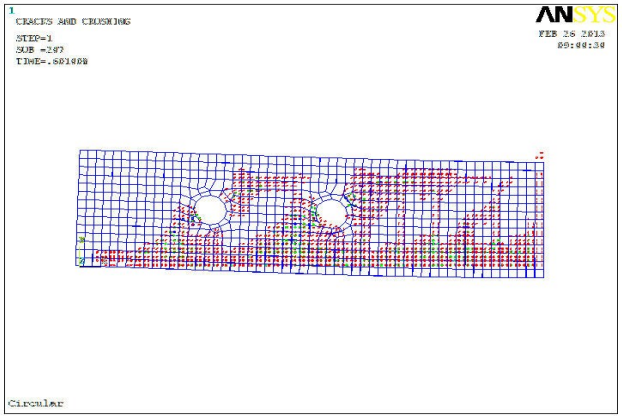


Figure 18: Crack patterns for model 7

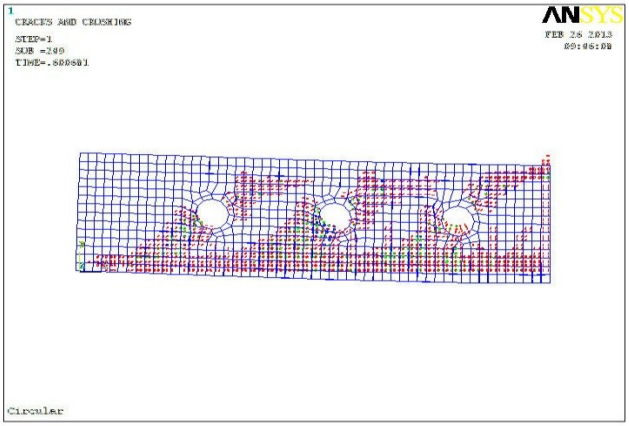


Figure 19: Crack patterns for model 8

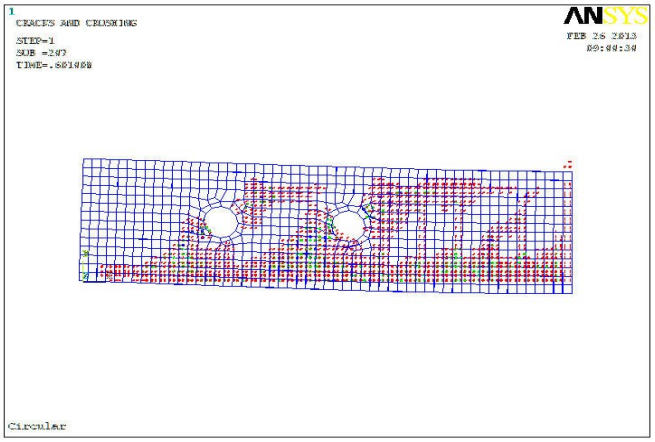
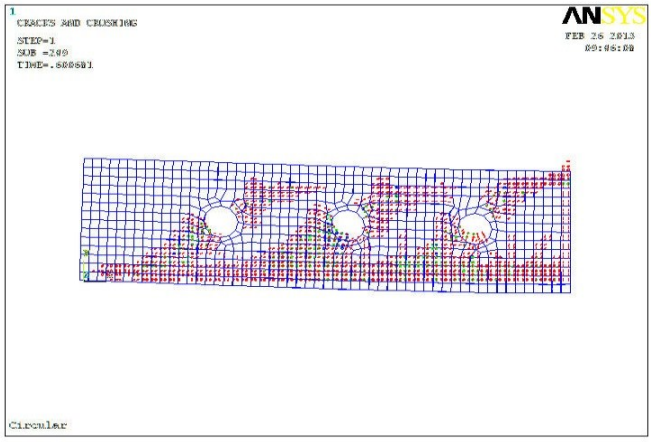


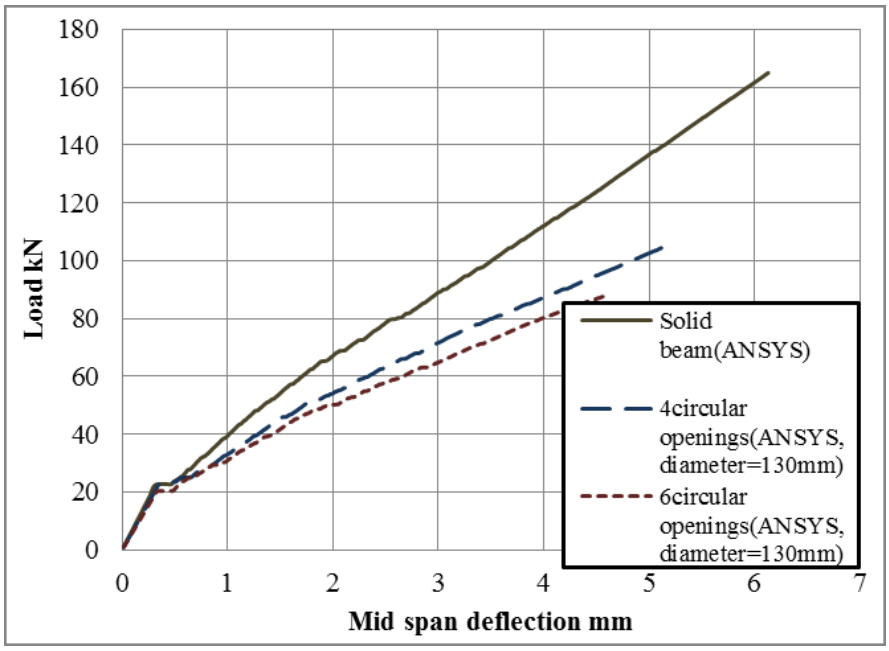
Figure 20: Crack patterns for model 9



5.1.4. Modeled Beams 10 and 11

Modeled beams 10 and 11 contain four and six circular openings respectively with diameter of 130 mm. The obtained results of these models in the form of load-deflection response were compared with the results of the solid beam as shown in Figure 21 .The predicted values of the ultimate loads of models 10 and 11 from ANSYS analysis were 106 and 87 kN, whereas the corresponding value for the solid beam was 165 kN, therefore introducing four and six circular openings with diameter equals 57% the web depth reduces the capacity of them by 36% and 47% of the solid beam respectively.

Figure 21: Load-deflection relationships for modeled beams 10, 11 and 1 (solid beam).



Crack patterns for models 10 and 11 are shown in Figures 22- 23 It can be noticed that the failure mode of these models is in shear at the opening regions.

Figure 22: Crack patterns for model 10

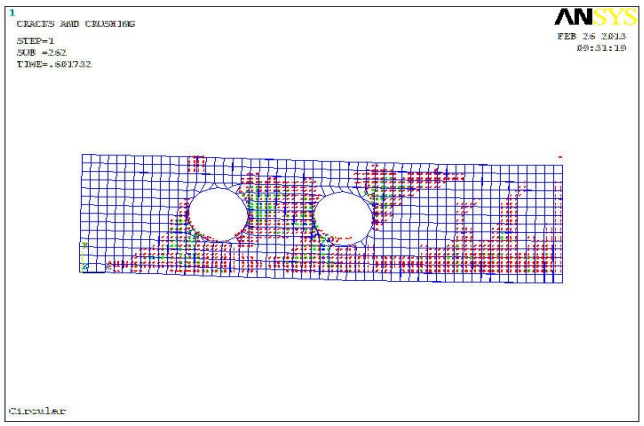
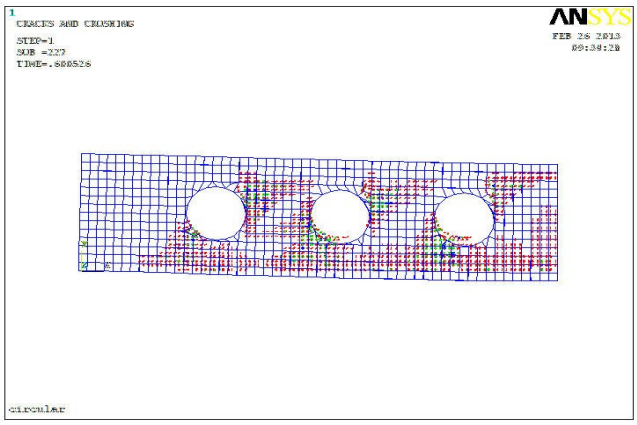


Figure 23: Crack patterns for model 11



Figures 24-25 present load-deflection relationships for all previous analyzed models. Table 3 gives the characteristics of the analyzed beams and the summary of the obtained results.

Figure 24: Load-deflection relationships for solid beam and models with four circular openings with variable diameters.

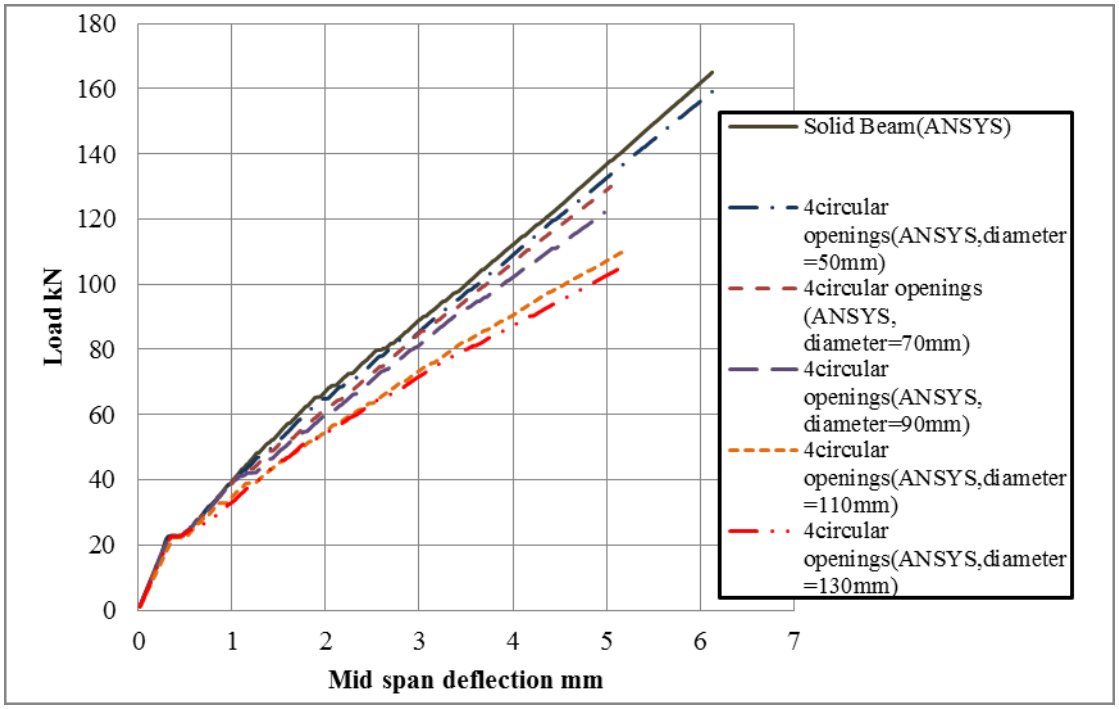


Figure 25: Load-deflection relationships for solid beam and models with six circular openings with variable diameters.

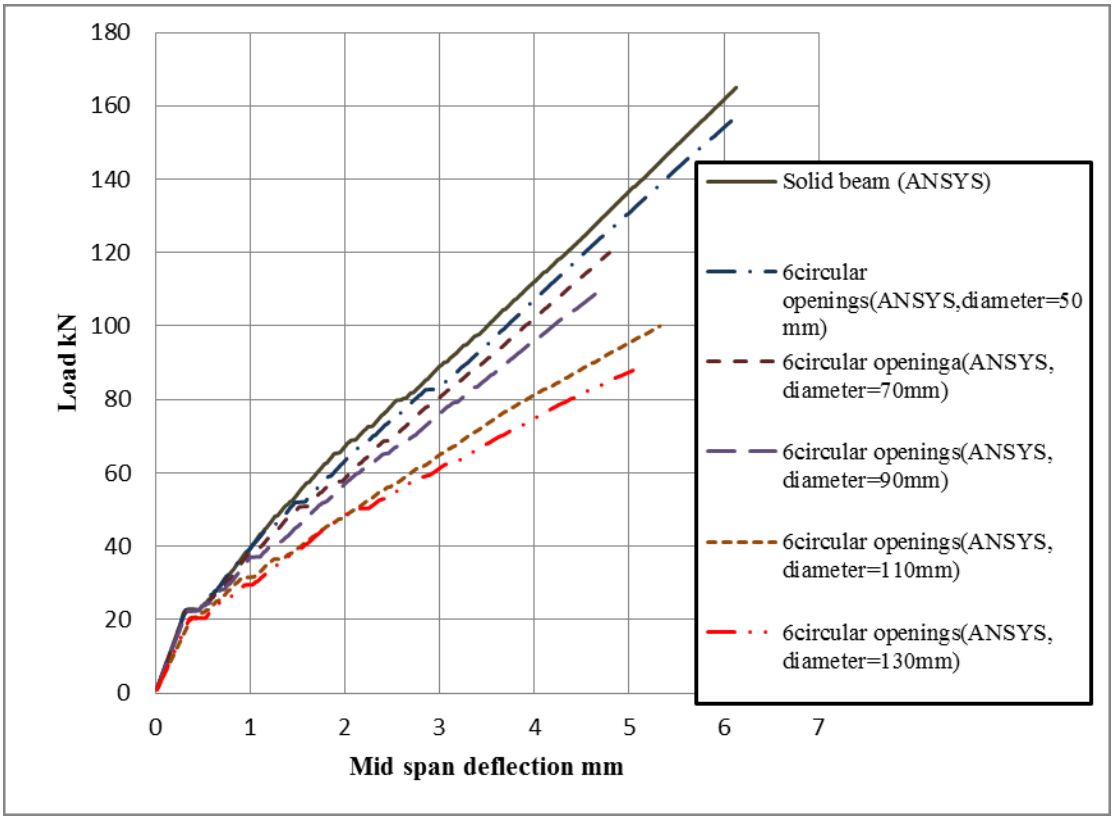


Table 3: Characteristics of the analyzed beams and summary of the results

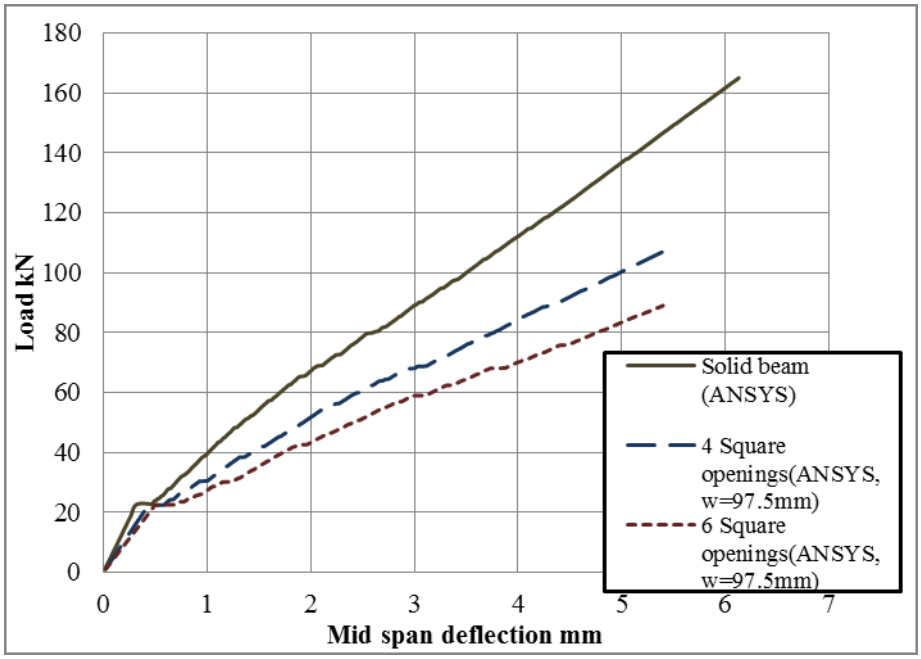
Modeled beam No.	No. of Openings	Diameter mm	Diameter/web depth ratio	Ultimate load kN	Percentage difference
1 (Solid Beam)	---	---	---	165	---
2	4	110	48	116	30
3	6	110	48	100	39
4	4	50	22	160	3
5	6	50	22	157	5
6	4	70	30	130	21
7	6	70	30	120	27
8	4	90	39	122	26
9	6	90	39	109	34
10	4	130	57	106	36
11	6	130	57	87	47

5.2. Effect of Equivalent Openings in Area to the Circular Openings

5.2.1. Effect of Equivalent Square Openings (Modeled Beams 12 and 13)

Modeled beams 12 and 13 contain four and six square openings equivalent in area to the circular openings with diameter =110mm (i.e. side length w=97.5mm). The load-deflection relationships of models 9 and 10 were compared with that of the solid beam as shown in Figure 26. The predicted values of the ultimate load for models 12 and 13 from ANSYS analysis were 107 kN and 89 kN respectively while the corresponding value for the solid beam was 165 kN; therefore, a reduction of about 35% and 49% occurs in the ultimate capacity of the solid beam respectively. On the other hand, the difference in ultimate load between circular openings (diameter =110mm) and equivalent square openings (w=97.5mm) were about 5% and 7% for four and six square openings respectively. This shows that the circular openings reduce the ultimate loads less than the equivalent square openings because the orthogonal corners of the square openings cause stress concentration at these corners.

Figure 26: Load-deflection relationships for modeled beams 12, 13 and 1 (solid beam).



Crack patterns for models 12 and 13 are shown in Figures 27-28. The diagonal cracks generally appear at the top and bottom corners of the web openings towards the load point and the supports and the failure mode of these models is in shear at the opening regions.

Figure 27: Crack patterns for model 1

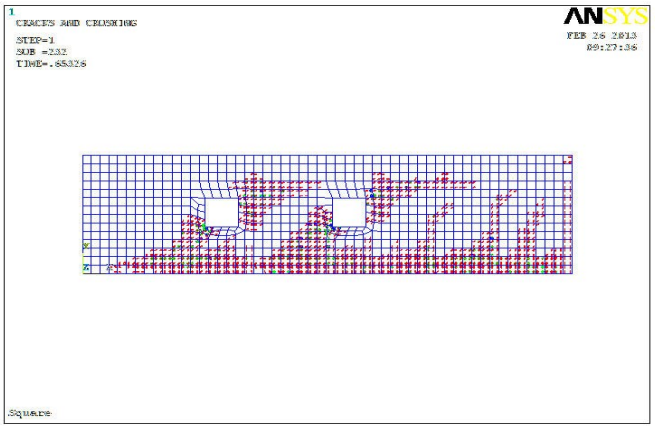
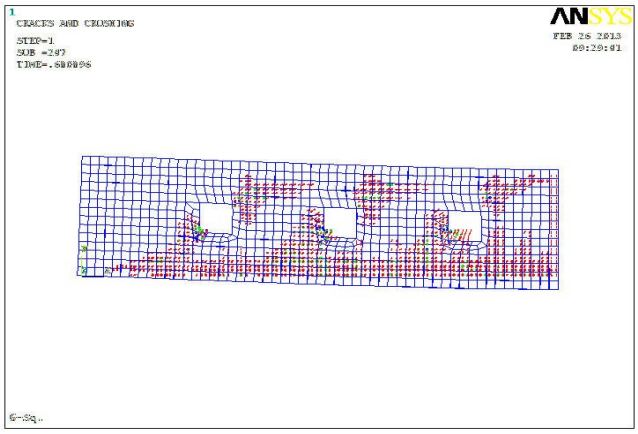


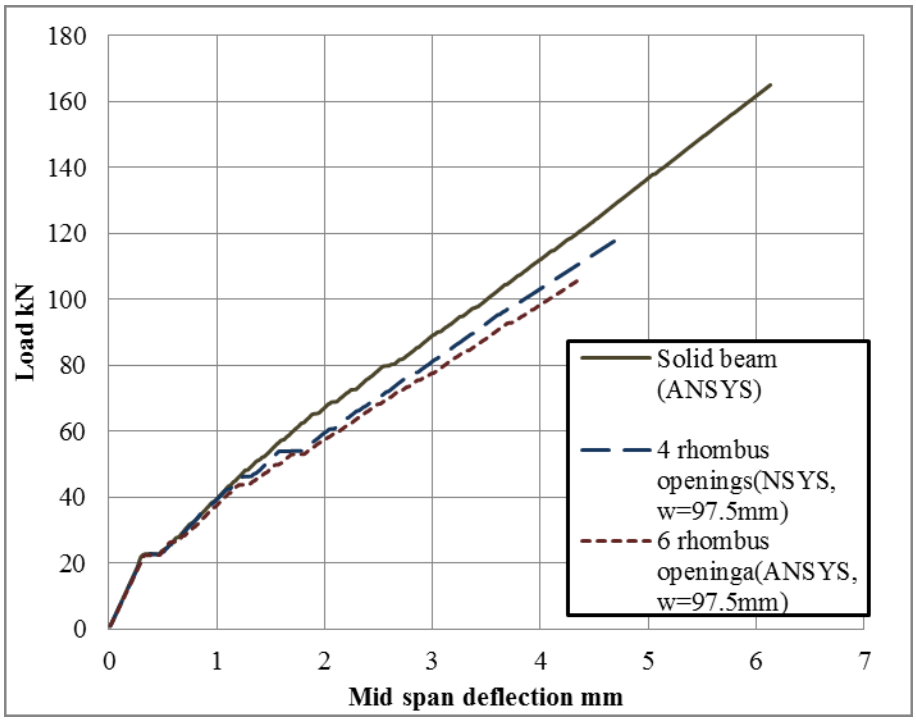
Figure 28: Crack patterns for model 13



5.2.2. Effect of Equivalent Rhombus Openings (Modeled Beams 14 and 15)

Modeled beams 14 and 15 contain four and six rhombus openings equivalent in area to the circular openings with diameter =110mm (i.e. side length w=97.5mm). The load-deflection relationships of models 11 and 12 were compared with that of the solid beam as shown in Figure 29. The predicted value of the ultimate for models 14 and 15 from ANSYS analysis were 118 kN and 106 kN respectively while the corresponding value for the solid beam was 165 kN, therefore, a reduction of about 28.5% and 36% occurs in the ultimate capacity of the solid beam respectively. On the other hand, circular openings cause reductions in ultimate capacity larger than the equivalent rhombus openings; the difference in reduction is about 1.5% and 3% for models 14 and 15 respectively.

Figure 29: Load-deflection relationship for modeled beams 14, 15 and 1 (solid beam).



Crack patterns for models 14 and 15 are shown in Figures 30-31. The diagonal cracks generally appear at the mid length of two sides of each opening and propagate towards the load point and the supports and the failure mode of these models is in shear at the opening regions.

Figure 30: Crack patterns for model 14

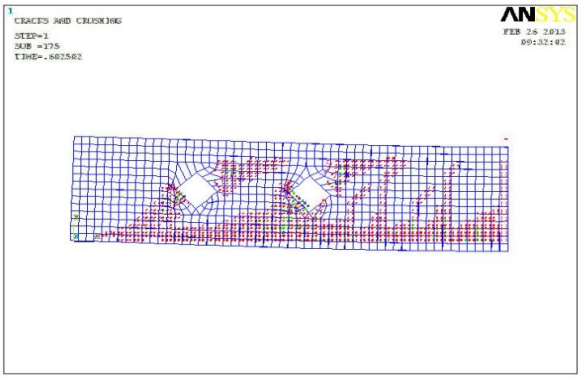
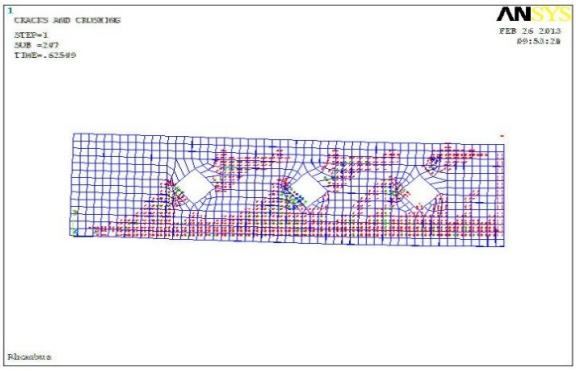


Figure 31: Crack patterns for model 15



Comparisons between load-deflection relationships for different shapes of openings with variables numbers are shown in Figures 32-33.

Figure 32: Load-deflection relationships for solid beam and beams with four openings of three different shapes.

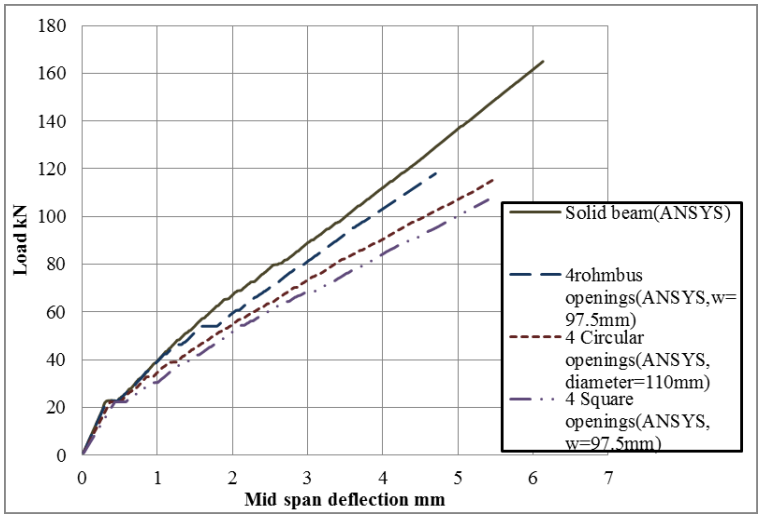
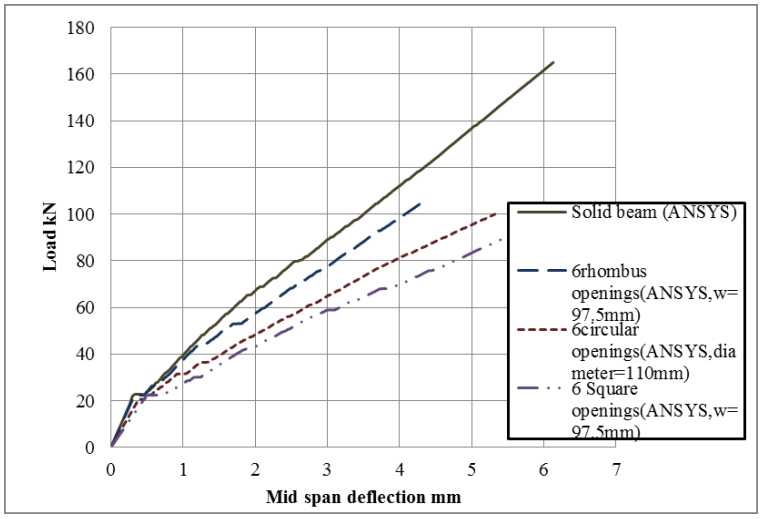


Figure 33: Load-deflection relationships for solid beam and beams with six openings of three different shapes.



6. Conclusions

The following conclusions can be obtained from the analysis of the solid beam, beams with multiple circular openings with 50, 70, 90, 110 and 130mm in diameter with variable numbers and beams with equivalent square and rhombus openings in area to circular openings with diameter =110mm :-

1. The ultimate loads obtained during experimental tests for three beams, solid beam and two other beams with four and six circular openings with diameter=110mm, are very close to the ultimate loads obtained from ANSYS analysis.
2. Introducing four and six circular openings with diameter equals 22% the web depth has small effect on the ultimate load capacity of the reinforced concrete T-beam (reduction in ultimate load capacity by 3% and 5% of the solid beam respectively).
3. Introducing four and six openings with diameter of 30% the web depth reduces the ultimate loads of the beams by 21% and 27% respectively while introducing circular openings with diameter of 39% the web depth reduces the ultimate loads by 26% and 34% respectively. Mode of failure is in shear at openings regions.
4. Beams with square openings have less strength than beams with equivalent circular openings with difference of 5% and 7% for four and six openings respectively due to the stress concentration at corners of the square openings.
5. Beams with rhombus openings have strength more than beams with equivalent circular openings with difference of 1.5% and 3% for four and six openings respectively.
6. The ultimate loads decrease as the numbers of circular openings increase from four to six openings in ratios depend on the shape and size of openings, the range of reduction is from 2% to 11%.

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